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EDITED BY J. McKEEN CATTELL

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THE SCIENTIFIC MONTHLY

AUGUST, 1923

SPENCER FULLERTON BAIRD AND THE UNITED STATES FISH COMMISSION[1]

By Dr. DAVID STARR JORDAN

STANFORD UNIVERSITY

I AM to speak to you to-night of one of the noblest of Americans, a commanding figure in New World science. More particularly, I wish to refer to certain episodes in Baird's life from which a moral may be drawn, and to stress somewhat fully a far-reaching project of his later life, the creation of the United States Fish Commission.

What I have to say must be largely a record of my own experience, for I can add little that is new regarding the character and work of Spencer Fullerton Baird. His life was all in the open, spent in the service of humanity. His letters have been lovingly edited by Dr. Dall. His books, papers and scientific notes, 1063 titles in all, I believe, have been duly catalogued. His methods and results have been reviewed by every student of birds, and have formed the solid foundation of the work of the Baird School of Ornithology, through whom we know the birds of North America better than any other faunal group anywhere else in the world.

I shall speak of the master as seen from my own viewpoint as one of the many struggling naturalists to whom Baird gave efficient and welcome help, even as Audubon, Agassiz and Dana had rendered aid to him. And, in passing, it is to me a matter of great personal interest and gratitude to recall here the names of the three men who contributed most, each in his way, to my own development. These are President White, Professor Agassiz and Professor Baird. I may also say that in 1849 Agassiz and Baird planned a beautifully illustrated joint paper on the fishes of North America. Six fine plates in stone by August Sonrel were prepared and printed, but as neither of the two authors had time to

[1] Address at the Baird Centenary, at the Smithsonian Institution, February 3, 1923.

complete the work, it was laid aside and left to me, forty years later, to furnish a text for the illustrations.

Glancing over Baird's early history, we find many things characteristically American. He was born of good stock, most of his ancestors deriving from the fine, strong, persistent, obstinate group of dissenters who left the dissolute England of the seventeenth century to build homes in the free air and harsh surroundings of a New World. All of them alike, Puritan, Presbyterian or Quaker, were men and women clear-eyed, conscientious and unafraid, who lived the religion they professed. It is true that they lacked some of the virtues desired in these softer times. Too often, for example, they reduced religion to terms of logic, and conscience to intolerance. Reasoning from their experience in the England of the Restoration, they usually associated art with vice and dissipation, as many artistic souls do even to this day. But their stern code of life left no place for the weakling or the slave. In spite of the criticism directed in these lax and war-worn days against the Puritans and their kind, it remains a fact that they created our republic; no other type could ever or would ever have done it. Far and wide their descendants have ramified through the land, while their combined influence forms our best defense against aggression, external or internal, against red revolution and black reaction. In the rising tide of illiteracy, so dreaded by timid souls, who ever heard of an illiterate son of the Puritans or of the sturdily-mingled seventeenth-century group of English and Scotch yeomen, among whom were the forebears of Baird?

Said Starr King of these people:

> When they found that all which civilization had done for the old world did not nourish, but threatened to crush their manliness, they came to the wilderness to show, on a background of ice, granite and famine, that humble devotion to duty, reverence for the right, and vigorous will make men masters of the world.

Born in Reading, Pennsylvania, a hundred years ago this very day, Baird grew up a big, handsome youth, a keen student, eager to know, eager to help and eager to put knowledge in order, and with an intense devotion to natural history. He was especially fond of the study of birds and mammals, though he later developed an almost equal interest in reptiles and fishes. We may also note that he began, not with biological theories or the intricacies of life-mechanism, but with exact observation of whatever he found around him. His experience illustrates, I think, the normal way by which a biologist should be formed: the study of organisms as present entities alive and active, or, if dead, illustrating through their structure their relations to other forms and to their environ-

ment. Agassiz used to say: "If you study Nature in books, when you go out of doors you can not find her." Books have their place of course—a great and vital place if anything original is to be accomplished, or any large work to be done. To make a permanent contribution, one must find out at last all that others have seen or thought. But books can not lead; contact with nature must come first. The same holds true with dissecting rooms.

For the last thirty years, and in the interest of lines of study supposedly more fertile—morphology, embryology, animal reactions, Mendelism and genetics succeeding each other in turn—the tendency has been away from the old-fashioned study of nature. Certain important pieces of research set the fashion for the others. Agassiz used to speak of those university students whose motto was "*Ich gehe mit den Anderen*" ("I go with the others")—a line of conduct repugnant to great minds. We find, however, in science as well as in art, a tendency to go with the others, or, as Dr. Coulter once put it in speaking of his contemporary botanists: "They all rush to dabble in the same pool."

In this vein, Professor James G. Needham,[2] of Cornell, sounds a note of remonstrance.

> We are all out of balance. . . . Why not let the facts speak for themselves? Our laboratories are full of fashions. They go from one extreme to another. In my high school days we learned systems of classification; in my college days we did nothing but dissecting; later came morphology and embryology, then experimental zoology, then genetics, and the devotees of each new subject have looked back upon the old with something like that disdain with which a debutante regards a last year's gown.

Nevertheless, there should be no question of the riches to be found in any pool of science. Every piece of honest research has its use, though not to the discredit of any other, and the refinement of taxonomy holds its place with the rest. Accurate knowledge of animal or plant species is the foundation of the great science of zoogeography, as well as of its cognate branch, ecology. It marks especially the route over which the great naturalists of the past have been led to their specialties. It is, moreover, the normal beginning for those men who are to follow.

In his biography of Baird, Dall lays special stress on this phase of the work. "The method of instruction, by actual field excursions, which Baird employed in his classes of zoology and botany was new in America, and an original innovation with him. It was not unknown in Europe, and Agassiz's employment of it a year or two later at Cambridge gave a vogue to it in America which has

[2] *Science*, XLIX, 1919, p. 457.

been permanent. . . . Many references to the long tramps with his pupils are found in his Journal."

Dr. William Morton Wheeler,[3] in a recent very clever paper on "The dry rot of our academic biology," expresses the same idea:

> Dear, old, mellow, disinfected professors of the type of Louis Agassiz, Asa Gray, Shaler, Hyatt and Ryder enter at once into sympathetic rapport with the humblest amateur, but the young or those of middle age are almost invariably more or less priggish, condescending or worse. . . .
>
> And especially in the college we are unfaithful to our trust if we allow biology to become a colorless, aridly scientific discipline, devoid of living contact with the humanities.

I thus quote with no intention to criticize those highly endowed specialists who, in their various fields, with marvelous technique have opened up new vistas of the mechanism of life nor of those who deal with technical fragments or quantitative methods. I wish only to insist that the budding biologist can not begin with such work. I believe that the intensive study of living things around us, carried on accurately, not in sentimental fashion, is a means of grace to every scholar and a first step in preparation for biological research. It is well also to remember that biologists deal with the whole realm of life, which can not be seen in perspective from any single corner.

In an address ten years ago on "The making of a Darwin," I maintained that three things were necessary to this end: First, the right kind of germ-plasm, the hereditary stuff which determines high possibilities; second, contact with nature at first hand; and third, the presence of a sympathetic guide. In Darwin's case the material was of the best the centuries offer; in due time, also, the young naturalist wandered among the hills and fens of Cambridgeshire, collecting beetles and observing everything; and, finally, as he said, he "walked with Henslow," the spirit of the great botanist kindling his own. In like fashion, young Baird had it in him to be a great naturalist; he made the hills and streams of Pennsylvania his laboratory, and he "walked" with Audubon and Agassiz.

Baird's life may be divided into three parts, though each period shades off into the next—first, that of student and teacher, second, that of investigator, third, that of administrator. In early years his struggles to develop himself as a naturalist culminated in a scantily paid professorship at Dickinson College. During the second period he came to the Smithsonian as the chosen helper of venerable Joseph Henry, the original secretary and virtual creator of the institution. Now began his revision and expansion of the

[3] *Science*, LVII, 1923, p. 61.

knowledge of North American birds from his studies of the rich material brought in by surveys, and the inauguration, wholly informal, of the "Baird School" in zoology. Later, as executive, he managed and developed several scientific bureaus and sent out frequent exploring parties, at the same time extending a helping hand to struggling naturalists and in various ways making research possible.

The first period is clearly revealed in the letters selected by Dall for his biography. The lad's enthusiasm over discoveries, his bent for intensive investigation as shown in his early monograph of the Flycatchers—the scientific spirit appearing in his interest in these dull-colored birds which appealed to him as strongly as the most comely of warblers—his reaching out for help, and a similar willingness to extend aid to others, all appear in that early record.

Baird's connection with the Smithsonian Institution dates back to 1850. To bring him there as assistant secretary had long been Professor Henry's plan. But lack of funds and uncertainty as to the future postponed the matter until the young naturalist reached the age of twenty-seven. In his letter of appointment, he was asked to "take charge of making collections for the Smithsonian Museum and to request of officers of the Army and Navy . . . and of other persons such assistance as he might think necessary for the accomplishment of the intended object." Out of these instructions has grown up, in the seventy subsequent years, one of the great museums of the world—a most notable center of work in ethnology and related fields as well as in zoology and botany.

For nearly two decades Baird was a most prolific writer in ornithology. In his efforts to clear up tangled and useless synonymy and to ensure accuracy in the recognition of species, he departed widely from the loose and general type of description by using a particular individual and then indicating with precision any deviations due to age, sex, geographical separation or other influences which might appear in other specimens. Such minute exactness made the definition of local subspecies possible, and went far toward establishing the theory that whatever other factors may occur in evolution, changes due to separating barriers constitute a main element in the differentiation of actual species. Many species of animals and plants will be found to vary interminably if deviations can be protected and segregated from interbreeding with the main stock. But in nature, as a rule, small or even large variations receive short shrift, no matter how important they might become in the farm, the garden or the greenhouse. Moreover, however wide the fluctuation, new forms are not species until they have "stood." As a matter of fact, for an intelligent discussion

of the origin of species we need in these days a fresh definition. Let me suggest that a species of animal or plant is a definable form which has run the gauntlet of the ages, struggling constantly for existence, and yet has *endured*. Variations of many sorts take place through readjustment of character units, but no product of man's protection and scientific ingenuity is properly to be called a "species" until tested in the race of life, however much it may resemble nature's product. It is of course as "natural" as a true species, but still untested in the matter of endurance in the open.

Baird was not a theorist and did not worry much over the origin of forms; much of his work antedated Darwin's illuminations. He described what he saw, and in such fashion that no subsequent observer had any doubt as to what he meant. This persistence in accuracy is the foundation of the Baird School of Ornithology, so ably represented by men like Elliott Coues, Robert Ridgway, John Cassin, Thomas M. Brewer and the rest. In related fields, among others who in some degree caught inspiration from him were Theodore Gill, G. Brown Goode, William H. Dall, Leonhard Stejneger, Tarleton H. Bean, Richard Rathbun, Charles H. Gilbert, Otis T. Mason and Frederic A. Lucas. These also did him lifelong homage; lovingly we called him "the grandfather of us all."

In the later expansion and development of the National Museum, Baird took endless and intelligent pains. Nevertheless, as the details of his management are so well known to my hearers and have been so fully described by G. Brown Goode, Dall, Theodore D. A. Cockerell and Charles F. Holder, I need not touch on them here. At the same time, no account of Baird's life is possible without special mention of G. Brown Goode, his most distinguished assistant, a scientific student of unique range of knowledge, compelling personal charm, and a degree of executive ability scarcely inferior to that of the chief himself.

The third stage in Baird's career may be dated from the organization of the United States Commission of Fish and Fisheries in 1871, when, in addition to his other duties, he was chosen by President Grant as the first incumbent of a new and wide-ranging responsibility. This position, honorary and without salary so far as Baird himself was concerned, brought his knowledge and influence into the direct service of the government, while the effort further constituted a most effective move for the preservation of wild life. It moreover gave him a vastly increased opportunity to assist young naturalists and to develop in the aggregate more research than he would personally have accomplished had he refrained from

executive burdens. Referring to his own scientific work, he once remarked to me: "Have I not done my share already?"

Says Dr. Holder:

> The appointment of Baird to this unremunerative position marked an epoch in the development of economic science in America, and the growth and evolution of the United States Fish Commission alone shows better than anything else the comprehensive views of its chief and his remarkable grasp upon questions requiring the highest powers of a systematist. His work showed that he was an organizer and administrator of the highest rank. For twelve years he devoted his energies to the arduous labors of the United States Fish Commission. He constructed the entire framework of the new department, and organized it under the following general plan: To prosecute investigations on the subject of the diminution of valuable fishes with the view of ascertaining whether any and what diminution in the number of food fishes of the coast and lakes of the United States has taken place, and, if so, to what cause the same is due and also whether any and what productive, prohibitory or precautionary measures should be adopted in the premises and to report the same to Congress.

The operations of the Fish Commission, modest at first, and confined to investigation along the Atlantic seaboard, soon expanded in many directions. Among these I may include:

A complete study of fishery methods, with collections of examples of nets, traps, spears and other devices of whatever order; the gathering of statistics of fisheries throughout the country; the scientific identification of all available species of fishes, with records of their geographical distribution; monographic reviews of different groups of fishes; the creation of fish hatcheries wherever practicable, with the distribution of spawn of young fishes in various waters, and to different parts of the world; the introduction of desirable new fishes from different parts of the United States and from Europe, and fish protection in all its aspects as well as the study of the various parasites, worms, crustaceans and protozoans which attack or infest fishes.

Most conspicuous of the efforts of exploration has been the work of the "Albatross," a naval vessel adapted for deep-sea dredging by the use of the beam trawl. In this way the deep-sea fauna of the Atlantic and Pacific coasts of North America has been explored, as also that of Hawaii, the Philippines and Japan. Material for the "Oceanic Ichthyology" of Goode and Bean, one of the most important contributions to our knowledge of abyssal life, was drawn primarily from the work of the "Albatross."

In the acclimatization of fishes, especially successful has been the transfer to the Pacific Coast from Potomac River of the shad (*Alosa sapidissima*), the striped bass (*Roccus lineatus*) and two species of catfish (*Ameiurus nebulosus* and *Ameiurus catus*), all of which are more abundant in their new surroundings than in Atlan-

tic rivers, their original home. In addition, the large-mouthed black bass (*Micropterus salmoides*) has been placed in many ponds along with a species of sunfish (*Lepomis incisor*) on which it may feed. The crappie (*Pomoxis annularis*) is now common in the Columbia River. In many lakes of the Sierra Nevada the eastern brook trout (*Salvelinus fontinalis*), the European or brown trout (*Salmo fario*) and the Mackinaw trout of the Great Lakes (*Cristivomer namaycush*) are also well established.

In return, the California Shasta rainbow (*Salmo shasta*) and other western forms find themselves thoroughly at home in the Great Lakes and elsewhere in the east. These American trout have been also established in Europe. In the market at Arlon in Luxembourg, for instance, I saw the Shasta rainbow, and the yellow-fin trout of Colorado (*Salmo macdonaldi*) has been naturalized in mountain streams of France. Still more surprising, I once found the common eastern sunfish or pumpkin-seed (*Eupomotis gibbosus*) in the Rialto market at Venice. But the introduction of the carp (*Cyprinus carpio*) into the United States was on the whole unfortunate, it being of low grade as food, rooting like a pig in the bottom of lakes and ponds, thereby keeping the water turbid.

With the growth and expansion of the Fish Commission came ultimately its change of name to the Bureau of Fisheries, and its transfer from independent existence to the Department of Commerce. To its headship Professor Goode succeeded in 1887. Since his death in 1896, the work has grown steadily in importance along lines of the original initiative, for the most part under wise direction. Its value, both to science and to human welfare, has been adequately demonstrated and its work has met with deserved appreciation.

Soon after the creation of the commission, Baird recognized the need of a marine laboratory where fishes and other sea forms could be systematically studied in life. Casting about for a location, he took his little steamer, the "Blue Light," the modest precursor of the useful "Fish Hawk" and the commodious and efficient "Albatross," to Wood's Hole in Massachusetts, then to Noank, Connecticut, and at last back to Wood's Hole, when the laboratory became, as Dr. Charles O. Whitman asserted, the lineal descendant of Agassiz's school at Penikese, conducted in the summers of 1873 and 1874.

For my own part, I first came under Baird's influence in 1874. Visiting Noank, I found the professor absent, but Goode, Richard Rathbun, a classmate of mine at Cornell, Professor Verrill, of Yale, and Alpheus Hyatt were there, busy making studies and collections. The laboratory at Wood's Hole, modestly opened next sum-

mer under such auspices, naturally flourished, becoming in a few years one of the best known and most fruitful marine stations of the world. I remember well Agassiz's delight in hearing one day from Baird that he had caught at Wood's Hole the rare spearfish of the Mediterranean, *Tetrapturus imperator*.

My first connection with the Smithsonian and the Fish Commission occurred in 1876, when I asked for the loan of a "Baird seine," one of the inventor's many devices, adapted for catching minnows and darters. In company with a keen-eyed lad, Charles Henry Gilbert, from that time a life-long associate, I ventured into the virgin field of Upper Georgia, a great state in which fishes had never been studied by any one. Baird now encouraged me to take up some one family and write a monograph of it, advice which I followed with several groups in turn. Dr. Coues suggested also that I should enter into scientific partnership with my best student rather than to attempt the heavy work as helper to some older man. "Jordan and Gilbert" accordingly set to work, and in 1882 developed a "Synopsis of the fishes of North America."

In 1880, Professor Baird sent me and Gilbert (as assistant) for a year's study of the fishes and fisheries of the Pacific Coast, under the joint auspices of the Census Bureau and the Fish Commission, an opportunity of the greatest value in the training of us both. In later expeditions under Baird's direction and with the cooperation of Professor Goode, I visited the Florida Keys and Havana, the coast from Pensacola to New Orleans and Galveston, the rivers from the Potomac to the Alabama, Tennessee and Cumberland, and those from the Des Moines to the Rio Grande, still later, Colorado, Utah and the Yellowstone Park. For all such expeditions by myself and my associates, the Smithsonian furnished nets and tanks, and paid actual expenses, no more. On these terms I was able to secure the best of service from devoted young men, such as Gilbert, Evermann, Swain, Jenkins, Meek, Fesler and Davis, whereas, had salaries been paid, the work would have been obstructed by insistence from greedy nephews of greedy congressmen. The spoils system was rampant in the years following the civil war, interfering with the accuracy and sanity of all government work, a fact which accounts for the unwillingness of Professor Henry to allow the government any control over the activities of the Smithsonian.

That this danger was real a single incident will show. In 1882, Baird conceived the idea that a naturalist might well be attached to the staff of the commandant of the Yellowstone Park for the purpose of careful observation of the elk, bear, beaver, porcupine and other inhabitants of this wonderful region. He therefore

asked me to suggest a good man, and I named Seth E. Meek, one of my advanced students in Indiana University. Our congressman, Mr. Columbus C. Matson, was at once interested, insisting on his right to nominate if any one from his district was put into public service.

His first candidate, however, could not possibly accept, being confined at the time in the Monroe County jail to expiate the social error of larceny. His second choice was a young man from the neighboring county of Morgan, who received the notice of appointment one Sunday morning when he was trying to spur a serious and remonstrant horse through the door of a Martinsville saloon! He afterward sobered up sufficiently to reach the Park, but soon died of alcoholism at Mammoth Hot Springs. Baird's excellent plan thus came to nothing.

The various ichthyological expeditions were continued in other waters by my colleagues and students, under the direction of successive commissioners. These efforts conformed to Baird's theory of utility in science. Knowledge loses nothing by acquiring human values, and research takes on a certain dignity by serving at once intellectual demands and human necessities.

I mention the matter, not for any personal reason, but as an example of the helpful relation Baird sustained on every side toward those he thought in earnest, and who would faithfully carry out any trust assigned. Any one who could really aid in "the increase and diffusion of useful knowledge" was freely called upon, the word "useful" being given its widest meaning.

In early days, budding naturalists were housed in the Smithsonian Tower, where for a time some of us did our own cooking. In 1877, while engaged on a report of the fishes of Ohio, I lived there with my artist, Ernest R. Copeland, now a physician in Milwaukee, brother of a most promising young naturalist, Herbert Copeland, who had died in Indianapolis the year before. Coming down from my eyrie one early morning I first met Joseph Henry, who appeared suddenly before the museum doors were opened, unaware that Baird's protégés were infesting the building.

As to his students and helpers, voluntary or salaried, Dall's words could be verified by any of us:

> In his relations with his subordinates Baird was admirable. Orders were given quietly and with consideration. His way with the young student was a mixture of fatherly oversight, kindly criticism and careful training. They came to him as to a father confessor, and the half humorous philosophy he installed in his advice was not only healing but wise. He was never profane, no one would have ventured on a risky story in his presence. I have heard that once or twice in thirty-seven years he was known to be angry, but it was regarded as an astounding phenomenon by all who knew him.

One of Baird's most cherished ideals was that of cooperating bureaus of science. He would have the various workers supported or aided by the government join together as associates and friends, not as rivals, in the increase and diffusion of knowledge. This meant the development of a special *morale* based on high principles which would give government service a dignity rare in other quarters of the capital. He would weed out all those who, in Cassin's words, "look on Science as a milch cow, rather than as a transcendent goddess." To a large extent he was successful in these aims, and it is not too much to say that in the eighties and nineties government science reached a degree of dignity and effectiveness it had not before possessed.

Of Baird, as of Simon Newcomb, his friend and colleague, it may be said that he left "a record wholly blameless and wholly salutary, whose work added to the only permanent wealth of nations." In the extension and coordination of human experience, in the widening of the boundaries of knowledge and in the attainment of greater exactness in the details, is found the permanent wealth of nations. All this constitutes the subject-matter of science; in science also we find the basis for the development of the finest of fine arts, that of human conduct.

AN UNRECOGNIZED FACTOR IN ALTITUDE EFFECTS

By Professor WITHROW MORSE
WEST VIRGINIA UNIVERSITY

THE increasing importance of the aeroplane, coupled with the sensational attempts of the British climbing party to reach the top of Chomolungmo, or Mount Everest, has emphasized the importance of our knowledge of the physiological effects of high altitudes. It is common knowledge that for most persons not accustomed to unusual altitudes a height of that of Pike's Peak in Colorado involves for them discomfort of intensity varying with the individual, physiological states or perhaps, better, pathological conditions which have been defined by Whymper, the Andean climber, as "nausea and vomiting, headaches of the most severe character, feverishness, hemorrhages, lassitude, depression and weakness." It is commonly believed that such conditions are met at more or less definite heights and that location and environmental features have nothing to do with it. The aviator, however, knows that he feels differently in a doldrum from what he feels when he is breasting the wind, and Alpine literature contains many references to the effects of stagnation of air and of temperature. It is to these that we shall turn in this paper.

The writer's attention to this matter was called by his experiences at rather low altitudes in the Wet Mountains of Colorado. In the particular region concerned, two valleys lead westward from the plains to the San Luis Valley, one known as North Creek, which throughout is broad and is protected from the prevailing winds by mountains which stand at 10,000 feet (3,048 meters), forming what in Wales is known as a corry and in mountain literature as CWM —a pocket; the other, known as Middle Creek, is "gun-sight" throughout, with high, rocky, almost perpendicular sides, but with no CWM at its head, having rather a funnel-like debouchment into the highlands to the westward. The sun reaches the depths of the canyon of Middle Creek only from about 10:30 until 2:30 and the wind is moving ceaselessly from the funnel, downward towards the plains. Contrasting this with the condition in North Creek, where the sun shines from an hour after its rise above the artificial horizon to late in the afternoon and where the wind is inhibited by the

high mountain masses, known as Scraggie and others, one sees that environmental conditions are distinct and characteristic.

It is the experience of the writer that there are corresponding physiological states in the two instances, for while he has never experienced the more definite forms of *mal de montagne* as defined by Whymper, whom we have quoted above, he has, at the same time, experienced lassitude, reluctance to take any unnecessary exercise and ennui during the traverse or North Creek, while alertness and vigor is the experience at all times in Middle Creek. The corresponding levels of altitude should guarantee similar feelings, but this is not so. North Creek, being of less abrupt gradient than Middle Creek, should cause less exertion and therefore less altitude effect.

These experiences, *in magna parte*, are reflected in such studies as have come from our great mountaineers.

The earliest mountain literature is that of de Saussure, who, during the years closing the 18th century, carried on researches in the Mont Blanc region of Savoie in France and elsewhere in Switzerland, his home. If one care not to follow the all-absorbing accounts of his life in the Alps in his "Voyages dans les Alpes," he may peruse the more recent volume by Freshfield, the hero of many mountain expeditions, "The Life of Horace de Saussure" (London: Edwin Arnold, 1920). In the climb up Mont Blanc, they ultimately reached the Grand Plateau shown, well, in the picture by Abraham in the *National Geographic Magazine* for August, 1913, and in crossing this expanse of snow—"an oval ravine, as it were, sloping very gently upward for about two miles to the base of a conical peak, the summit of the mountain, its sides being formed by lofty walls of snow-covered rock, its entrance guarded by two almost perpendicular walls and its bottom full of snow that has fallen into it for ages"—the men exhibited all the manifestations of mountain sickness, although they were men inured to the altitudes of the Chamonix region and although the altitude of the Plateau was not of great magnitude. It is the experience of the average climber of Mont Blanc that this particular part of the climb is what gives characteristic physiological effects not met with at even greater heights on the Matterhorn, the Rothhorn and on other mountains of the Alps and which cause the average mountaineer to consider Mont Blanc more difficult of climb than other mountains.

The reader of the Life of Thomas Henry Huxley will recall that Huxley's attempt at Mont Blanc with John Tyndall ended ignominiously at the hut of the Grand Mulets, for the exhausting climb over the flat névé above the hut was too hard for the renowned

scientist, who found too much of London's smoke in his body for strenuous climbs in the higher reaches of the Alps.

In Mallory's account of the reconnaissance of the highest mountain in the world ("Mount Everest, The Reconnaissance, 1921," New York: Longmans, Green and Co., 1922), the effect of heat and stagnant air is described: "We had also been greatly interested by the phenomenon of fatigue. The most surprising fact when we applied our standard of comparison was that we got along better when we remembered to breathe hard and we already suspected what was afterwards established—that it was necessary to adopt a conscious method of breathing deeply for coming down as for going up. Another inference, subsequently confirmed on many occasions, accused the glacier. The mid-day sun had been hot as we crossed it and I seemed to notice some enervating influence which had not affected me elsewhere. It was the glacier that had knocked me out, not the hard work alone, but some malignant quality of the atmosphere which I can neither describe nor explain; and in crossing a glacier during the day I always afterwards observed the same effect; I might feel as fit and fresh as I could wish on the moraine at the side but only succeeded in crossing a glacier without feeling despairing lassitude."

Turning to other parts of the world, we find Edward Whymper in his "Travels" in Ecuador considering similar effects. He was climbing the great cone Chimborazo which rises 21,425 feet above the sea. He had reached 16,000 feet without any signs of illness. "We were all in high spirits, which was to be expected as we had ridden most of the way." The guide, Carrel, an experienced Swiss guide, "selected a position for the second camp with much judgment, at the foot of a wall of lava, which perfectly protected the tent on one side." The results were disastrous. "In about an hour, I found myself lying on my back, along with both the Carrels, placed hors de combat and incapable of making the least exertion. We knew that the enemy was upon us and that we were experiencing our first attack of mountain sickness." Inasmuch as this was what Whymper came to Ecuador to find and to study, we can not mete out much sympathy. At this time, Whymper took a dose of potassium chlorate, $KClO_3$, the great oxygen content of which being probably what gives relief, having been introduced by Henderson into mountain medicine during his expedition in Kashmir. However, the use of this drug is of questionable desirability, for 15 grams (half an ounce) have been fatal and even in small amounts, methemoglobin is formed, which actually imitates carbon monoxide in its effects, lowering the oxygen-fixing powers of hemoglobin. The guide, Carrel, adopted another therapeutic agent,

"wine—red wine, when heated and beaten with raw eggs, provided it is drunk while looking over the left shoulder . . .," but Whymper never had the patience to hear the rest of the recipe.

Strikingly similar experiences were felt by Sir Martin Conway in his trips through the mountain lying north and east of Kashmir, in the region of the great K_2, the second highest mountain in the world. "One can lie on one's back and not believe by any conscious discomfort that one is not at sea-level. But let a single gleam of sunlight fall upon the tent and everything is changed. A headache probably appears upon the scene." Again: "The connection between heat, still air and human discomfort at high altitudes is a close one and calls for explanation. A climber is forced to take account of it. In attempting the ascent of a high peak, he should, if possible, approach by a north and south valley so as to win as much shade as possible and then he should endeavor to climb by an exposed ridge rather than by gullies or snow slopes, for thus will he the more probably avoid stagnant air. Finally, he should work in bad weather and by night as much as possible." In his climb up Pioneer Peak, from which he could look out over the sea of peaks from K_2 to India and Mongolia, he spoke of the "terrible heat which the burning rays of the sun poured upon our heads. . . ." There was plenty of air upon the actual ridge and now and again a puff would come down upon us and quicken us into a little life; but for the most part we were in the midst of utter stagnation which made life intolerable." Not only were these experiences felt by Conway, but by Bruce, one of the most remarkable mountaineers of all time, and by the guide from the Alps, Zurbriggen.

Let us turn to some of the physical factors to account for these phenomena.

If the temperature of the tent at sunrise be 10° C., that is, 50° F., the air density will be 0.1247 and if the sun within a few minutes, as well it may, in the higher altitudes, where the thin air permits the full value of the rays to become evident very quickly, endow the air within the tent with a temperature of 20° C., a rise of 10° C., the density has fallen to 0.1204 and at 30° C. (86° F.), another rise of 10°, the density has further fallen to 0.1164. Now the density of the air changing from 0.1247 to 0.1204 is a change similar to what one experiences when estimating the density of air-samples taken a thousand feet apart in altitude and a difference of 8 per cent. as between the air with a density of 0.1247 and 0.1164 is similar to a vertical rise in altitude of over two thousand feet. Hence, if one is resting in a tent at an altitude of, say, 16,000 feet, as in Whymper's case, and the sun shines, increasing the temperature of

the close, static air 20° C., it is equivalent to his being suddenly transported to an altitude of 18,000 feet, with corresponding lower oxygen tension in the air and accompanying lowered oxygen utilization in the body. Accompanying this, sunlight increases the metabolism of the body considerably, making more need for oxygen. Little wonder, then, that the effects of altitude are accentuated!

It is worth while to look farther into the specific procedure which is going on in the case of mountain sickness. Loevenhart has shown at the University of Wisconsin that anoxemia, that is, the want of oxygen, leads to the accumulation of acids in the body. The body is normally slightly alkaline and kept so by a delicate mechanism of chemical nature whereby the phosphates and carbonates of the blood take care of the excess acid as it forms. The carbonic acid of our breath is thrown off, relieving the so-called "alkali reserve," that is, the chemicals just mentioned as protectors against acids and leaving these chemicals to cope with acids which are not volatilized and thrown off, in the breath, of which lactic acid, a normal product of muscular action, is a conspicuous one. The carbonic acid of the blood is never permitted, normally, to accumulate and if there is a sudden production of this compound, as when we start up a hill, the increased acidity of the blood, due to the carbonic acid, comes into contact with the regulatory center of the brain, the so-called "respiratory center," and stimulates it to increased action, and accelerated ventilation of the lungs ensues, that is, we breathe more frequently and more deeply. Hence, the CO_2 is thrown off. Not so, however, with the lactic acid, and the more the muscles work, the more lactic acid there is produced. This acid is taken up by the alkali reserve and the combination is thrown off via the kidneys. If there is excess acid production, this alkali reserve is depleted and may become dangerous. In the disease, diabetes mellitus, there may be plenty of oxygen, but the powers of the body to utilize the oxygen are weakened, so that the result is the same as if there were an oxygen want, and whenever this occurs, the fats, especially, but also the other constituents of the body fail to be oxidized completely to carbonic acid and water; and these acids of incomplete combustion, known familiarly to the physiologist as the aceton series (aceton, aceto-acetic and hydroxy-butyric acid) arise and have to be taken care of by the alkali reserve, which may not be adequate to the task; and hence there is an accumulation of acids, and in the later stages of diabetes, the patient may die of coma or intoxication from the accumulated acids which can not be taken care of by the depleted alkali reserve. These same compounds form in the case of lowered oxygen supply, as in severe exercise and in altitudes where the oxygen

tension is low. In mountain climbing, then, we have the acid test, that is, Can the organism take care of the acids formed while there is not enough supply of alkali reserve to take care of these additional and dangerous acids? There is one other point in regard to the tendency to the accumulation of acid in the blood and that is, as Barcroft and others have shown, the power of the blood to hold oxygen is lessened as one passes from a normal alkaline blood to one where the acids have depleted the alkali reserve. Hence, as one mounts to higher altitudes, the lowered oxygen tension leads to acid formation which lessens the power of the blood to hold oxygen. The heart seeks to compensate for the increased demands made upon it, as Eyster and Meek, also at Wisconsin, have shown recently; for with the heart pumping at 5,900 cubic centimeters at rest, during exercise, it may increase its output to 10,750 cubic centimeters. The actual sickness of mountain "sickness" is undoubtedly due to the heart, for, as workers at Cornell Medical College in New York (Hatcher and Weiss) have demonstrated, the heart has direct relation, by way of the nerves, to vomiting and nausea.

The question is asked whether man will ever be able to climb Everest. Two climbers of the British expedition of 1922 approached to within two city blocks of the top, using oxygen from tanks which they carried with them. An oxygen supply, then, is adequate, but other conditions have to be met with, which will be overcome and we shall read some morning of the conquest of the greatest height on the globe's surface. Whatever may be the solution, it will have to do with what we have called "The Acid Test."

PLANTS WHICH ATTRACT POPULAR ATTENTION[1]

By O. A. STEVENS

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For several years one duty of the writer has been the identification of numerous plant specimens received at the agricultural college with requests for information concerning them. Naturally, a large proportion of these have been weeds, and the inquiries have been regarding the name, nature and method of eradication. In this group it has been interesting to note the seasonal variations in the plants received. Other variations have been due to publicity which has been given to some particular plant.

Another group of inquiries comes from teachers who have had their pupils prepare collections of plants and wish to have the specimens identified. These usually include our common prairie plants or weeds and sometimes bring interesting notes on vernacular names.

Poisonous plants are a never-failing source of interest and fascination. Since North Dakota is a comparatively dry prairie region, mushrooms comprise a very small proportion of specimens received, although a favorable period of weather usually brings a few of them. Stock-poisoning plants, on the other hand, are of much interest, and every year brings a number of cases suspected to be due to poisonous plants. Most commonly the plants submitted are not known to be of poisonous nature. One lot, collected in a marshy place in search of water hemlock, consisted of duckweed, cattail, long-rooted smartweed (*Polygonum emersum*), tall white aster (*Aster paniculatus*) and water parsnip (*Sium cicutaefolium*). Another contained three species of bulrush, marsh marigold (*Caltha*), meadow-rue, meadow-parsnip (*Zizia*), horsetail and a buttercup, in addition to water hemlock, which is the one really to be feared.

In North Dakota the most important poisonous plant is probably the water hemlock (*Cicuta maculata*). Comparatively few cases of stock poisoning have been traced to it and none of human poisoning so far as the writer recalls in his experience in the state. The plant, especially its roots, is one which is known to contain a virulent poison. The roots have a pleasant parsnip-like fragrance,

[1] Photographs by R. C. Corbett, college photographer.

FIGURE 1. FALSE LUPINE

(From pressed specimen.) The stalk at the left has two flowers at the right of the uppermost leaf. The other stalks have young pods, and a mature pod is shown at the right.

and it is not at all strange that occasionally children have made the sad mistake of eating them. The dried plant in hay, however, does not seem to cause trouble, else we should have more trouble with it, as it is common in many low places. The non-poisonous water parsnip (*Sium cicutaefolium*) is much more common here and is extremely similar to water hemlock in general appearance.

At least three species of loco are found in the state, one of them (*Oxytropis lambertii*) abundantly, but they do not seem to cause much trouble, and very little inquiry is received regarding them.

FIGURE 2. CUT-LEAVED NIGHTSHADE

(From pressed plant supplied by Mr. Ralph W. Smith of Dickinson, N. D.) This specimen shows only a few immature berries.

The false lupine (*Thermopsis rhombifolia*), which is common in the western part of the state and bears showy yellow flowers in late May, is suspected of causing some cases of stock poisoning. The dwarf form of the poison ivy (*Rhus rydbergii*) is very common, growing not only in woods and thickets, but also in the open in many places and even on buttes. Scarcely any inquiries are received regarding it.

Medicinal plants stand in close relation to poisonous ones, and of course many species are on both lists. These have been the source

of but few inquiries, although an occasional ginseng letter is received, the plant being usually the false spikenard (*Aralia nudicaulis*). A few years ago one correspondent was growing a plant which was a sure cure for hog cholera, having been brought from Europe by a farmer. The material was jealously guarded, however, and its identity was not learned.

Perhaps it is a wise provision of nature that people are imbued with an impression that almost any wild berry or mushroom is likely to be poisonous. Species which actually are poisonous are few, but certainly it is safer to leave them alone unless one knows. Regarding the poisonous or edible nature of wild fruits, quite a few inquiries are received. One of the most prominent of these with us is the cut-leaved nightshade (*Solanum triflorum*), which is common especially westward. This species as well as the common black nightshade (*Solanum nigrum*) has been on the poisonous list for a long time. Like so many other species of the family they seem to contain a small amount of poisonous material.

The black nightshade is found occasionally in eastern North Dakota but has not attracted attention. Its berries are eaten by many people and seem rarely if ever to cause ill effects. It may be remarked that the name "deadly nightshade," so frequently applied to this plant, belongs to the species yielding the drug belladonna (*Atropa belladonna*) and is a European plant not found in America.

The cut-leaved nightshade has berries which are somewhat larger than those of the black nightshade, and which remain green in color. Many inquiries are received regarding them, but I have not been able to find any one who has eaten them. Data on their effect are lacking, but some trials made here last year by feeding the berries to sheep gave negative results.

Another fruit which has brought a few inquiries is the wolfberry (*Symphoricarpos occidentalis*). This is a very common native plant growing in woods, thickets, slight depressions or on the open prairie, and bears an abundance of small white berries scattered along its slender branches. One letter received some time ago and an item seen in a newspaper indicated that cases of poisoning had been caused by these berries. No evidence of poisoning from them seems to be on record, but it is possible that a glucoside might be responsible for the trouble. One man informed the writer that he had seen horses eating the fruits.

The sheepberry or black haw of our region (*Viburnum lentago*) also has been the source of a few inquiries. The bush is found frequently in the eastern part of the state. The black berries are sweet and pleasant to the taste in late fall, but contain only a small

FIGURE 3. WOLFBERRY WITH MATURE FRUITS

The larger branch is from a vigorous bush which reached a height of three feet. The smaller one shows the more common size and position of plants growing in the open.

amount of edible matter. During the past fall several specimens of the berries of carrion flower (*Smilax herbacea*) were received. One correspondent stated that the children had picked them along with wild grapes and wondered what effect they might have upon the jelly. The berries have a not unpleasant taste and probably are harmless. Gilmore states that they were eaten sometimes by the Omaha Indians. The hard, bright red seeds are interesting and would seem to have possible use for ornamental purposes.

Another correspondent sent the subterranean seeds of the hog peanut (*Falcata comosa*) and wished to know the possibility of cultivating them. He had been informed that along the Missouri River they were valued for hog pasture. The slender vines and woodland habit of the plant would seem to preclude their cultivation in any ordinary way, but the writer has found them altogether too prolific in a wild flower bed. These underground seeds grow one in a place on thread-like branches from the nodes of the stems. They are irregular in shape and from two to several times as large as the beans found in the pods of the ordinary flowers. They were used extensively by the Indians, who usually robbed the stores of the wood rats and field mice to secure them. Gilmore states that the Dakota women maintain that they never took them from the mice without leaving some corn or other food in return.

Out of a total of 290 letters with plant specimens for identification during the year ending July 1, 1922, 200 have been concerned with weeds. As a matter of fact it is difficult to classify them exactly, since the letters frequently do not mention the term "weed," and some plants might or might not be so considered. Other plants distinctly not weeds are sent sometimes because of their resemblance to known weeds. Material identified from seeds only has been classified as "seeds examined" and not as plants identified.

The plants identified in these 200 inquiries belonged to 86 different species, of which over one half (47) were received but once. The ones which appeared most commonly and the number of times are listed below:

Quackgrass (*Agropyron repens*)	39
Leafy spurge (*Euphorbia esula*)	19
Goat's beard (*Tragopogon pratensis*)	16
Frenchweed (*Thlaspi arvensis*)	12
Buffalo bur (*Solanum rostratum*)	11
Blue wild lettuce (*Lactuca pulchella*)	11
Prickly lettuce (*Lactuca scariola*)	10
Canada thistle (*Carduus arvensis*)	10
Perennial sow thistle (*Sonchus arvensis*)	10
Tansy mustard (*Sophia intermedia*)	8
Sweet grass (*Savastana odorata*)	7
Western wheatgrass (*Agropyron smithii*)	5
Little sage (*Artemisia frigida*)	5
Prairie thistle (*Carduus undulatus*)	5

FIGURE 4. CARRION FLOWER IN LATE FALL
After the leaves have fallen, the large clusters of berries are conspicuous.

It might appear upon first thought that such a summary would present a fair survey of the weed flora of the state. A careful study, however, shows that while a certain amount of information is furnished by the list, it would be quite misleading to depend upon it without other information. There are many different reasons why weeds attract attention, and neither the abundance nor injury caused by the different species is shown accurately by such a list.

The most recent list (unpublished) of the weeds of the state prepared by the writer contains 226 species. A number of these are introduced plants which have been collected only once or twice and have not become established to any extent, if at all. Others are native plants which might or might not be classed as weeds. In a similar list published eight years ago (now out of print), some of these less common or unimportant ones were omitted, and the total number was 180 species. A bulletin recently published (N. Dak. Exp. Sta. No. 162) includes twenty-nine of the most important weeds, together with seven others often confused with certain of them. Since some weeds have entirely different habits from others, and some are especially troublesome in certain districts, it is not possible to arrange the species in order of their weediness to one's entire satisfaction. Different people have different ideas as to which is the worst, consequently any list of a certain number is quite sure to have one or two which could be dropped out and others substituted without affecting materially the value of the list.

A comparison of the 275 specimens received with the three lists just mentioned gives the following results: About one third of all are included in Bulletin 162. Half as many more belong to the seven secondary species included in the same bulletin. Thus, one half of the total number were covered by this publication. Of the remaining one half, four fifths are in the 180 species list. This leaves twenty-three specimens belonging to twenty-one different species still unaccounted for. Fourteen of these are missing from the 226 species list; they are nearly all native plants which were not regarded as weedy enough to be mentioned.

It may be considered, perhaps, that the list of thirty-six represents a quite successful selection in that it includes half of the total number which occasioned inquiry. A further comparison is of interest. Fourteen species of the thirty-six (nearly one half) are not represented among the inquiries; six others by one specimen only, and three more by two specimens. This probably indicates that the commonest weeds are well known and have not occasioned inquiry, while the questions pertain chiefly to identification of unknown plants. Ten of the species described in Bulletin 162 have been

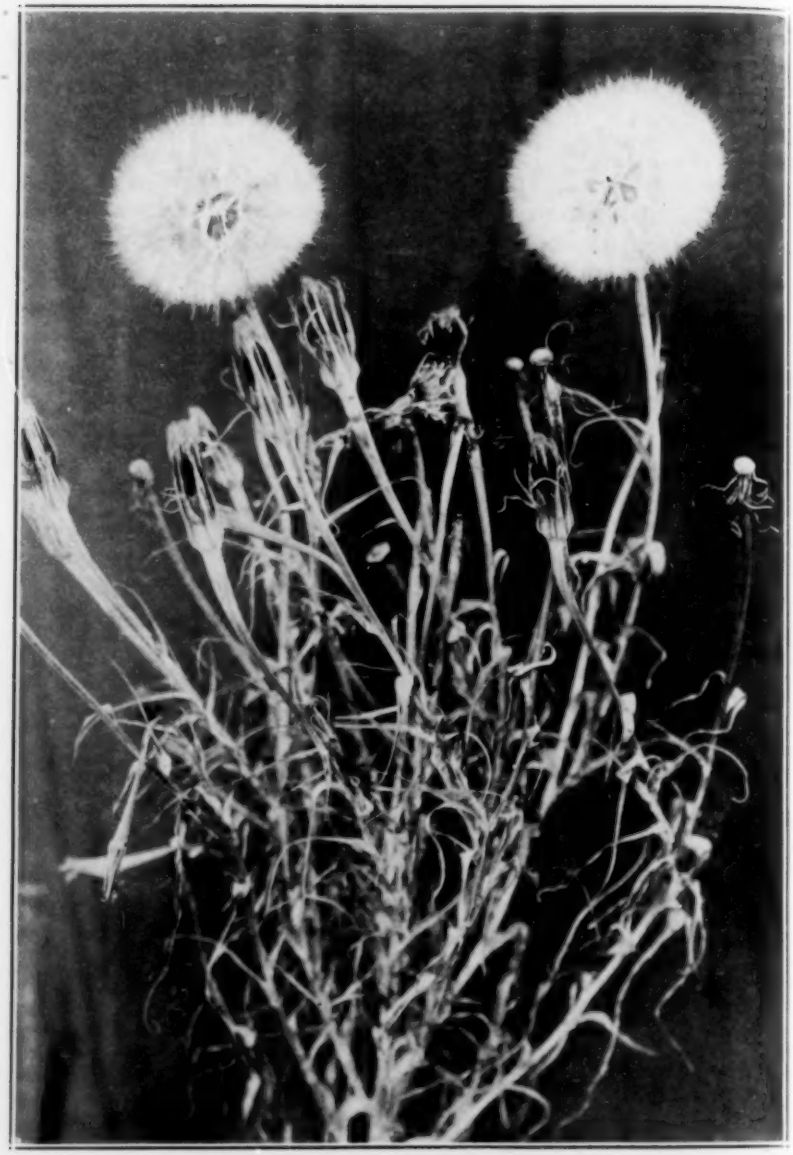

FIGURE 5. GOAT'S BEARD

Showing two expanded fruiting heads, several nearly ready to expand and several naked receptacles from which the fruits have blown.

received five or more times; most of those which have been received fewer times or not at all are among our commonest field weeds.

Why, then, have these ten species been the source of half of the total number of specimens received? These plants are quackgrass, leafy spurge, Frenchweed, blue wild lettuce, prickly lettuce, Canada thistle, sow thistle, sweet grass, western wheatgrass and prairie thistle.

That quackgrass should stand at the head of the list, with twice as many specimens as any other, is due to several reasons. In two or three cases several specimens from different fields were sent and each of these has been counted. The plant is justly feared on account of the difficulty with which it is to be eradicated. Its abundant rootstocks are very characteristic and can not fail to attract the attention of any observing person. But probably the greatest amount of the inquiries are due to the fact that positive identification is difficult. Western wheatgrass is a native plant common all over the state; its flowering spikes and rootstocks are quite similar to those of quackgrass, and the identity of one or the other is a continual question which the weed expert is called upon to settle. Sweet grass is another plant which comes in the same way. Its rootstocks are somewhat like those of quackgrass; its flowering panicles are quite different, but coming very early in the season they are not available for comparison. Neither sweet grass nor western wheatgrass are considered bad weeds, although either may cause some trouble at times.

The case of leafy spurge is difficult to explain satisfactorily. It was found in North Dakota for the first time in 1909. Since that date it has been collected at a number of localities representing a wide distribution over the state and has caused an increasing number of inquiries. This evidence suggests that it has been spreading rapidly, but of its origin and method of distribution we know nothing. Its seeds are not wind blown and have never been found in crop seed samples examined by us during the period covered. The plant is not especially conspicuous, although the pale green bracts of the flower clusters are rather different from any of our other weeds. It is a plant which we have been watching with some concern since it spreads by the roots. These would be likely to attract attention if seen.

Frenchweed is the only one of our most important annual weeds which appears in the list received five or more times. This may be due largely to its ill repute, as it is one of the most troublesome of the mustards. Its seed pods are somewhat conspicuous, and its habit of flowering very early in spring and late in fall is prominent. Often the seedlings are so crowded in certain spots that they make

very little growth. On one occasion some of such dwarfed plants were brought in, and when identified the man replied: "But I have Frenchweed all around these." These, he thought, must be something different.

Blue wild lettuce is a very common native perennial which is rather persistent under grain crop farming. It is perhaps the most important of our native weeds, but it has attracted attention more on account of its resemblance to sow thistle. The blue flower heads are quite different from the large yellow ones of sow thistle, but the leaves of the two plants are much alike, especially the small basal ones. The milky sap and persistent roots constitute further similarities. Prickly lettuce also has received attention because of its having been mistaken for sow thistle and will be discussed later in that connection.

Canada thistle has held a prominent place in the weed literature of the United States for many years, and no surprise will be expressed that it appears in the list. The plant has been known by this name for so long that it is probably useless to reiterate here that the name field or creeping thistle which is applied to it in other countries is more appropriate. "Field" is the literal meaning of the specific name arvense which was given to it two hundred years ago by Linnaeus, who remarked that it was one of the worst weeds. Also, it is almost the only one of our true thistles which is a prominent field weed or which has running roots. The common prairie thistle (*Carduus undulatus*) of our region is frequently confused with it, and this fact, rather than its prominence as a weed, accounts for the attention which the native plant has received.

The perennial sow thistle is the one weed which has been given much publicity in the state during the past few years on account of its alarming advance into new territory and the damage caused by it when once established. The number of specimens of the plant which have been received are not at all proportional to the agitation concerning it. This fact is brought out still more strongly by the specimens received from July 1 to August 15, 1922. During that time twenty-seven letters brought prickly lettuce and eleven spiny sow thistle (*Sonchus asper*), an annual species of less importance. Most of these letters inquired whether the plant sent was sow thistle, and not a few cases came as a result of disputes over the identity of the plants.

During the same period only four plants of the perennial sow thistle were received! The writer interprets the evidence as showing that much interest was taken in the question, and many people who were not acquainted with the plant sent specimens of what they thought might be it. The real plant was usually recognized

when found. With two exceptions the prickly lettuce came from localities where the sow thistle either is absent or not common.

During the year eleven different species were received with the inquiry whether they were sow thistle. Of these, spiny sow thistle, gumweed (*Grindelia*), prickly lettuce, false dandelion (*Agoseris*), goat's beard, hawk's beard (*Crepis runcinata*) and yellow rocket (*Barbarea vulgaris*) all have yellow flowers, and those of some of them much resemble those of sow thistle. Why the yellow rocket should have been suspected is difficult to explain, except that it was a new, unknown plant. The other plants sent do not have yellow flowers, but Canada thistle and prairie thistle are prickly, while the leaves of blue wild lettuce and of western lettuce (*Lactuca ludoviciana*) somewhat resemble those of sow thistle.

It is evident that there was much interest in sow thistle, but that it did not result in a large number of specimens of the plant being received. One of the most interesting cases was that of the false dandelion, the root of one plant having been pierced by a rootstock of western wheatgrass. Thus the specimen possessed a large yellow flower head and a running root, two essential characters advertised as distinguishing the species to be looked for.

The remainder of the plants received five or more times are not included in the list of thirty-six weeds in bulletin 162. Scarcely any other plant has attracted more attention than goat's beard, which has been represented to an increasing extent in the correspondence of the last two or three years. The writer believes that this is not because the plant is increasing rapidly, but rather that it is a result of the sow thistle campaign or of a general increase of interest in weeds. The flower heads of goat's beard are much like those of perennial sow thistle, also the plant has a milky sap. Further than this there is little resemblance, but the fruiting heads which expand like a giant dandelion to a diameter of six inches are probably the feature which has attracted most of the attention. Many correspondents have expressed the opinion that it was increasing rapidly and becoming a bad weed. This hardly seems probable, as the plant has been known to occur in the state for many years. Its habit of growth is not such as would indicate a troublesome weed and it is not so reported from other places, although it is a plant of very wide distribution.

Buffalo bur seems to draw about the same amount of attention year after year. It is frequent in the southern part of the state, and appears occasionally elsewhere, probably introduced in crop seed, as its seeds are frequent in millet seed grown farther south. The general appearance of the plant is quite different from that of any of our other species, and this, together with its prickly nature,

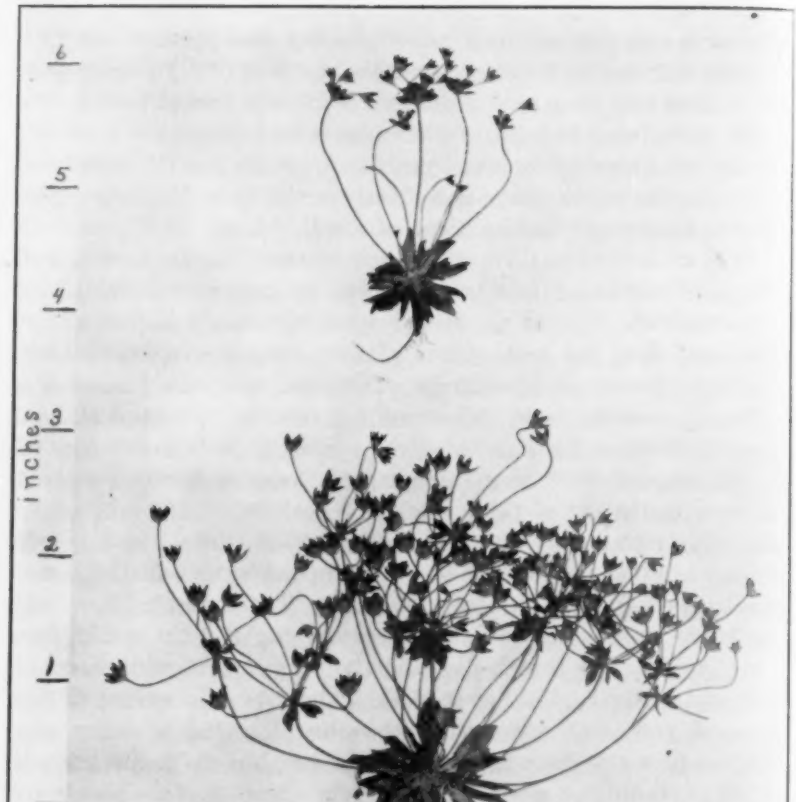

FIGURE 6. ANDROSACE, A PLANT WITHOUT A COMMON NAME
Upper plant represents the early flowering condition (May 6); the lower one has mature seeds (May 23).

is undoubtedly what draws attention to it. There is no evidence that it is increasing in abundance, and it is not at all likely to become a bad weed in this region.

Tansy mustard attains a considerable size and is abundant in places under favorable conditions. It has been suspected of being a bad weed, but this is probably due to the fact that it is conspicuous during a short period of its growth. The appearance of little sage in the list is due to the fact that it is a very common prairie plant, readily seen at any season, and almost certain to be picked up by any one making a random collection of prairie weeds. The fragrance of the plant may have something to do with it also.

Of interest to the writer has been the receipt of several plants which one scarcely would expect to be called weeds. One of these is *Androsace occidentalis*, an early flowering plant which sometimes fairly covers the ground in places, but grows only two to four inches high. The flowers are very inconspicuous, the tiny white corolla being almost entirely hidden by the calyx. A western species (*A. puberulenta*) also has been received. This has somewhat larger flowers which are fairly conspicuous if seen at the proper time.

A surprise of the past summer was *Lavauxia brachycarpa*, one of our evening primroses, which until four years ago was known from only one locality in the state. In 1918 the writer found a few plants at a second place in the same part of the state. During the past summer it was received with the statement that the farmer who brought it in regarded it as a bad weed in the corn field. The plant has a general habit of growth much like a dandelion, the leaves also similar but narrow. The specimen sent was an entire plant with a thick cluster of pods on the crown. When suspended by the root it reminded one of a Portuguese man o'war (*Physalia*). The species was received later from two other localities in a different part of the state, but not specifically as a weed. One specimen of mouse tail (*Myosurus minimus*) was received but without statement as to whether it was regarded as a weed. This, also, is an insignificant plant which is rare in this state.

In 1917 North Dakota began a campaign for the eradication of the common barberry, which is regarded as an essential alternate host for the black-stem rust of wheat. Since 1919 this work has been continued by the United States Department of Agriculture. At first, efforts were directed against the known large plantings of hedges and bushes, and to a canvass of towns. Since 1919 farm-to-farm surveys have been carried on in 37 counties, with the result that a surprising number of bushes have been found in a state which was believed by most people to have but few of the plants.

Thus the question has received a very wide publicity, and hundreds of people have become curious to see this plant of which they have heard so much.

One of the general accusations against weeds is that they carry diseases of cultivated plants. In this respect barberry is a weed, and the writer's experience is that it is so classed by the majority of the people. In the past five years he has conducted weed exhibits at county fairs in ten counties and many times a day the question was asked, "Have you got a specimen of that barberry bush?" Very often that was the one weed they wished to see.

As in the case of sow thistle, specimens of various other shrubs have been received with the inquiry as to whether they might be barberry. During the year in question these included wild rose, wild olive (*Elaeagnus argentea*), wild liquorice (*Glycyrrhiza lepidota*), dogwood (*Cornus*), buffalo berry (*Lepargyrea argentea*), prickly ash (*Xanthoxylum*) and red haw (*Crataegus*). One specimen of common barberry was received. One might think that a wild rose would be known to every one. Be that as it may, our plants are quite subject to a species of rust (*Earlea speciosa*) which produces conspicuous masses of cluster cups on the leaves and young stems, and it scarcely is strange that they should be a source of suspicion. The red haw, likewise, bears upon its leaves the cluster cups of the cedar rust (*Gymnosporangium*). The wild liquorice very often has its leaves completely covered with the brown spores of its particular rust. The leaves of wild olive and buffalo berry are covered with scales which give them somewhat of a rusty appearance. The prickly ash at least has thorns and small yellow flowers, but no special reason is apparent for dogwood.

We see from this survey that plants attract attention from a variety of reasons, and that the number of specimens received with inquiries may be an index to their abundance or importance; but on the whole it is rather more likely to be an unreliable guide. Publicity given to any particular plant causes suspicion to rest upon others which may have certain points of resemblance to it. Every one must have a "first time" at which he becomes acquainted with a particular plant. After this he notices it readily, and he is quite likely to interpret this as indicating that the plant is becoming more common.

CREATIVE EFFORT AS A FACTOR IN HUMAN EVOLUTION

By Professor **RALPH E. DANFORTH**
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UNTIL recently I have considered man of to-day the "missing" link or intermediate link between the ape and the finished man of the future. On fuller study of man and many other animals I am inclined to think man still an ape, with some individuals well started on the road to manhood.

Zoologists often speak of birds as glorified reptiles, and indeed to any one who has worked much on the anatomy and embryology of reptiles and birds the fact is very evident. Similarly, we speak of man as a glorified ape, but here the relation is much closer, for while reptiles, birds, apes and men all belong to the same Phylum Chordata, reptiles belong to the class Reptilia, birds to the class Aves, while ape and man belong not only to the same class Mammalia but also to the same order Primates. Some people are indeed "glorified," but the *average* man, squatting in squalor, is a long-legged, big-brained ape without any glorification.

Most of us think of man as a finished being, different from all the animals, finished and fixed, the same yesterday, to-day and forever. Only one finished man has walked this earth, some centuries ago, to show us what a man is.

We speak glibly of *human nature* as though it had been and always would be the same, like some mathematical quantity, yet paleontologists know that but yesterday it was very different, and we may fully expect it to be very different in the future.

Man's *creative efforts* have had much to do with this change, and will have even more to do in future.

Creative effort is the attempt to produce something new, something vital and living. It may express itself through sex or through the mind or heart. Some people seem to have more originality, more creative force than others. All who possess it feel the need of expressing it. Too many waste it.

Nothing can be more useful in making the man of the future than creative effort. Expressed through sex it can accomplish much; expressed through mind and heart it can accomplish just as much; both are needed, but not always of the same individual. Fortunate it is for the individual possessed of abundant creative

vigor that expression of the same through the mind is so satisfying. Study or the exercise of the learning process will not satisfy it. Imitation will not satisfy it. Repetition and recitals will not satisfy it. But efforts to produce either through art or through writing or speaking something new and vital, with the sincere desire and belief that it will produce a real and lasting result for good, these are creative efforts; these, if exercised systematically and regularly and if properly fostered, bring joy and peace to the most ardent creative personality.

Before considering creative effort in the production of the ideal man of the future, all thoughtful people will admit that man's creative efforts and genius have shaped the man of to-day and built our environment and civilization. We have got away from nature pretty far, too far, some think.

The women of the past evidently liked bearded men, with great bushy growths on their faces. Woe unto us men of to-day who like clean, smooth faces! We are thankful, however, that the men of the past had better judgment in selecting smooth-faced, pretty women to be the mothers of the women of to-day. Oh, the hours we spend on shaving, and the venom wasted cussing the dark stubs perpetually menacing the clean face! Fortunately, both sexes were prudent enough to choose mates with increasingly hairless bodies, as the generations flew past, until the being of to-day, with merely rudimentary fur, was produced, and a great advantage gained over our enemies the parasites and dirt. It would have been well if the *cheerful disposition* had been as universally sought and reproduced as the smooth body, but fortunately there are many who possess this priceless hereditary trait.

In hundreds of other ways reproduction and selection have made us what we are, mentally, physically and morally, but for the sake of brevity I must pass the subject on to your own fertile minds with the foregoing suggestions, feeling sure that you will all handle it quite adequately.

Other forms of creative genius have done much to vanquish nature, and too often destroy her, and to build our precious civilization. We have built magnificent homes and great cities, and constructed machines and industries concerning which we ourselves constantly marvel. In fact, so great are we, we can not understand our own greatness.

Yet the average man still squats in squalor, or tags along a slave to the will of others and a slave to impulse and whim. What is to be done with all this greatness and with the vastly greater mass of apish impotence?

By his creative efforts man is continually changing things around him, sometimes for better, sometimes for worse. In many

things he has improved on nature: vegetables, grains and fruits are very superior to wild forms from which they were developed. The milch-cow, beef animal and pig have also been made to produce more nearly what man wants of them. On the other hand he has laid waste thousands of miles of park and forest land, stripping, scorching, allowing priceless soil to wash away.

Instead of spreading out and using these fair lands man congests in great masses, paying more for a small lot of city land than would have bought a whole forest before it was spoiled. There he fills the air with dust and smoke, and pays his agents to go out and despoil more remote lands. He can not see far; his atmosphere is so besmirched. He is not interested in far scenes, grand views nor visions of the future.

What is to be done, I repeat, with all this greatness, and with the vastly greater mass of apish impotence?

Creative effort, is the answer, directed comprehensively yet simply—comprehensively enough to include the whole world in its scheme, and the whole future, also, yet always simply, for the simple things are best.*

There is to-day creative effort enough in the world to make this world a paradise, and to make of man right speedily an ideal being.

What should man be? What would he most like to be? *That* may he quickly become. What should this world be? *That* man can quickly make it.

We agree that man has done much to make the man of the present, and to fashion the world of the present, and we likewise agree that he can continue to do so for the man of the future and the world of the future. Let us first consider the man of the future and then the world of the future, although in actual practice the two should be attended to simultaneously.

In making the man of the future, why not make him very superior instead of mediocre? Heretofore, we have been satisfied that our offspring should be as ourselves, or we may even have selected mates which we acknowledged to be inferior to ourselves in some respects.

To rapidly improve the race, it is not necessary to overturn social ideals nor to disregard the sacred family relationship, but rather to raise our social ideals to even higher levels and to make even more sacred the family tie.

The sacred marriage privilege belongs only to those worthy of so high an honor. To be a father or a mother one ought first to be pure and strong and intelligent and joyous and thoroughly sound in body and character; and one ought always to have been

so, and to have sprung from parents and grandparents that were so.

Divide a land, like overpopulated, struggling Porto Rico, in which I live, into three parts. Let each of the three parts receive equal favor and care from the government. Let each have its agriculture, its arts and industries, its businesses and education. Let each be improved, made sanitary and benefited in every possible way—in one part the unmarriageable males to live their lives, cultivate their fields, transact their business, study or teach in their schools and colleges, have their societies and "batch it," as men love to do when they are well fed and prosperous, and have plenty of male companions, lots of work to do and business good; the unmarriageable girls and women in another part; they have proved to the world in recent years that they can do everything that man can do, and do it well. Agriculture, business, education, art, music, government—everything would flourish in their domain, as in that of the men.

The third part, for the married folk, well stocked from the first—because it would not do to sever bonds already formed—would remain well stocked, although no additions would be made to the lists of the married until the candidates had been passed upon by a triple committee. The sub-committees would be experts in things physical, mental and moral, respectively, and would not only pass upon the individual candidate but also upon his forebears.

The three parts would be securely fenced apart, and the third part would also require a subdividing fence during the lifetime of those already married who could not meet the requirements of the examining committee, in order to prevent any possible contamination of those who had passed the examinations. The third part would become an undivided unit as soon as the undesirable ones within it died. All children would be examined at some time before marriage, and would be either permitted to marry or transferred to their respective unisexual territory. Many minor details and complications arising would be provided for by regulations so kindly and humane as to make living conditions far happier than they actually are now, when critically examined.

As generations succeeded, and the health, intelligence and morals were brought to higher levels under this rigid elimination of sickly, stupid and immoral strains of heredity, the standards of the examining committee could be raised. The optimum rate of increase, also optimum total population might be factors influencing the conditions imposed by the examining committee.

Let us recall that we are considering creative effort as applied consistently to the improvement of man and his world. Having

drawn in outline a plan for improving man himself, let us turn to the world in which he lives.

A tenth part of the constructive thought now being employed building up great industries with their elaborate buildings, complex machinery and vast business organization would, if directed primarily toward creating an ideal environment, make the world we live in so much more beautiful, healthful and altogether joyous that we would hardly recognize the old ball; or, better said, we of the present would again recognize in it the Mother Earth of the Greek poets, transfigured with new loveliness and made safer through advancing culture and enhanced simplicity.

None of the main stream of creative effort has been turned to this purpose; only the ripples and eddies play upon it here and there sporadically. No truly vast, far-reaching and comprehensive effort has been directed on this goal. The goal has been sighted by many a prophet, poet and writer. Too often it has been put in some far-away utopia, and oftener still relegated to a future existence. Yet already more remarkable results than this have been accomplished by man, tasks more truly stupendous. Some of these achievements are of but partial or even doubtful value to the race, yet wonderful.

The beautification and sanitation of the whole world, both town and country, is relatively simple in nature, if vast in extent. Compared with the complexities, intrigues and agonizing intensity of the great war, it is simplicity itself. Its organization and successful prosecution would require no more men, money, brains and effort than any one of the seven greatest businesses in the world, or of the seven greatest governments in the world. Yet which could we spare best—the ideal world or the individual business or governmental organization referred to?

Many, many times the amount of engineering and business achievement have been consummated which would be required to eliminate slum conditions the world over, remove the dust nuisance from town and country, control mosquito and other nuisances of temperate and tropical zones, and restore forests to their rightful places and beauty to each eyesore where the hand of man has shown more zeal than inspiration.

A youthful leader, with the ability and genius of a John D. Rockefeller, could, by devoting his life, organize the men, the brains, the means and the concerted effort, put the movement on a sure foundation, and start it forward and upward with an impetus which eternity itself would never stop.

At the present moment, man has reached a stage in his evolution where he is ready to receive and cooperate with a concerted,

consistent effort to quickly, scientifically and sanely improve the human hereditary stock and the physical environment we live in. The double improvement will react, one part upon the other, the improved environment accelerating the upward evolution of man, and the new-born supermen will appreciate more fully and evaluate more accurately and truly the worldwide movement toward a perfect environment. Then it will require but a few centuries more when every denizen will be a perfect man, perfect in physique, intelligence, ability, absolute joyousness, interest, spirit and every way, and the world about as fine as heaven itself.

It is a long road from the first one-celled organisms—neither plant nor animal, neither protophyte nor protozoan as yet—to the highest organisms of the present, and the voyage has occupied many millions of years. On the tree of life to-day are many things, lovely and unlovely, and among these, here and there, are some buds of great beauty and promise. Are some of these buds really men—or what are they? Will the sun shine upon them, and the breezes blow, and will the needed sustenance be furnished from below and the needed gifts from above, and will they open into flowers of true manhood? Look a moment again at the opening words of this little paper.

THE USE OF TROPICAL LAND AND TROPICAL FORESTS

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To judge the productive capacity of any given region involves the consideration of a complex of geographic factors. These can be divided into two groups, phyto-geographic and homo-geographic. The first have to do with the potential possibilities of any given area to produce crops. The second considers the intelligence of man to utilize successfully the natural crop-yielding capacities of the land and an economic pressure that would force him to use this intelligence in order to survive.

There is probably as much arable land in the tropical as in temperate regions. In some tropical regions, where economic pressure due to heavy population forces it, the arable lands are fairly well utilized, but, generally speaking, the agricultural methods are crude and the yields are far below the potential capacity of the soil and climate.

It is generally conceded that the power of the tropical sun to store up energy in the form of agricultural and wood crops is greater than that of temperate sun. This is due to the fact that heat and moisture are available the year round, whereas in temperate regions they are lacking a part of the year. In fully utilized tropical soils, with certain climates, two crops of corn or rice can be raised in a year, each yielding as much as the one crop that is obtained in temperate regions.

An acre of ground in the Hawaiian islands yields per year five times as much cane sugar as does an acre in Louisiana. The ratio of Porto Rico to Louisiana is about 4 to 1 in favor of the former. In comparing crops rich in starch, like potatoes for temperate regions and cassava for tropical regions, we find that the gross yield of the tropical product in tons per acre is two to three times as much as potatoes.

In moist regions of the tropics the cattle raiser has a great advantage over his temperate neighbor engaged in a like operation, for his cattle can feed on rich nutritious grasses the year round, thus saving the expense of harvesting a crop for winter use.

Figures concerning the relative capacity of the two regions to produce crops of timber are inadequate as yet. Such as are avail-

able indicate that in the production of valuable fully stocked stands of hardwoods an acre of ground in the tropics has a capacity of three to four or more acres in temperate regions. Expressing it more concretely, if it takes 100 years to produce a fully stocked stand of oak of a given amount in New England, for instance, the same amount of mahogany can be raised on similar soils in the tropics in 33 years. The ratio between Spanish cedar and oak is estimated as one to four in favor of the former; between balsa wood, a tropical tree, and cottonwood, two very fast-growing trees, it is one to six in favor of the balsa.

The ratios given above indicate that under the equally intelligent direction of man, lands favored with a tropical sun have two or more times as much power annually to produce crops than do lands receiving the energy of a temperate sun.

Actually, however, the average per acre yield of used lands in tropical countries is much below the actual capacity of these lands. This is due to the homo-geographic and not to the phyto-geographic factors. The average intelligence of the native tropical farmer is much below that of the temperate farmer; as will be shown later he is only one step in advance of the stone age of farming. In spite of this, it is believed that if statistics were available they would show that even under unintelligent direction, the used land of the tropics is producing nearly as much per acre as the used lands in temperate climates. Nature makes up for the inefficiency of man.

Lack of products of a kind that could not be raised in temperate zone climates, such as cane sugar, bananas, rubber, coffee, cacao, cocoanut, material for cordage and high grade lumber, forced the white man into the tropics. At first he went as a trader depending on the products that the native brought to the markets. As soon as he found that the supply of any particular product obtained in this way did not equal the demand, he furnished capital to raise his own crops, as in the case of sugar, rubber, bananas and coffee. Where nature already provided a crop as lumber, he introduced modern lumbering methods.

Each year finds the economic interdependence of tropical and temperate countries more pronounced. With this the closer utilization of tropical lands is increasing. The question arises whether, if economic pressure demanded, tropical lands could be brought as near their capacity to yield produce as temperate lands. If they could it would mean a great deal to the future economic development of civilization. If an arable acre of ground in the tropics is equal to two acres in the temperate zone, a very conservative estimate, and assuming that the arable area in the tropics is equal to that of temperate regions, it means that, fully utilized, the lands

can furnish twice as much to feed, clothe and house the population of the world as the latter.

One method of increasing the production capacity of tropical lands would be to colonize them with the races from temperate countries. This has not been done successfully. The failure is usually attributed to the climate, but other controllable factors undoubtedly have their effect. One of these is the unhygienic conditions that prevail in the tropics, due to the ignorance of the population, the lack of medical attention and a properly balanced ration. All these reduce the general efficiency of tropical people and raise the mortality rate. What would be the mortality rate and general inefficiency of a temperate community if it were to be cut off from the benefits of the highly organized civilization of today? Would the climate alone save them? One has only to point to the present conditions in Russia as an example. If the per capita distribution of competent medical men were anywhere near the same in the tropics as in temperate countries and fair sanitary measures were enforced, we would hear less about the climate, per se, being an unfavorable one for the temperate man.

The cleaning up of the tropics is one of the principal white man's burdens. Up to date the cleaning up process has been mainly piecemeal with the prime motives of preventing diseases from spreading into temperate regions or to aid the economic and political penetration of the tropics by the white man. Indigenous populations of the tropics have been incidentally improved in this civilizing influence.

In the land-colonization process, material and to some extent political, social and religious improvement is the prime motive that controls migrations from one part of the globe to another. The movement is up hill and not down. Unless it can be demonstrated to the average man with the hoe that he can be benefited materially he is not going to a country with cheaper labor than the one from which he comes. Chinese temperate labor goes to the tropics for two reasons; it finds living conditions in the tropics often better than at home, and other temperate countries, where living conditions are best, are closed to him. For the last reason, Japanese temperate labor is reluctantly colonizing some tropical countries.

Thus it is seen that not one but many factors direct the migration of peoples. Up to the present time the white race has not gone to the tropics as settlers, because temperate lands with political, social, religious advantages are still open to them. When these are closed—they are rapidly being closed—he may find tropical lands more attractive than now.

But we do not have to look to colonization of tropical lands by the white man for their better utilization. Economic pressure

advancing southward from the United States, Europe and to some extent from Japan is doing it. Under the tutelage of temperate man each year finds an improvement in the use of these lands.

In tropical countries under control of European governments there has been no general attempt to educate the native population in all lines of endeavor. The assumption is that tropical people generally are not capable of being so educated, though schools of some sort exist. The keynote of such governments is material prosperity, the home governments benefiting largely thereby. In American tropical possessions, education rather than economic exploitation is the keynote of the development. In the Philippines, for instance, for the first time tropical people have been looked upon as being capable of something besides the white man's errand boy. The Filipino is given a chance to show whether he is as much inferior to the white man as the white man generally believes him to be. He is being taught to develop himself physically, mentally, morally, agriculturally and industrially. Vocational training, athletics, moral responsibility in the affairs of government, hygienic instruction are all a part of the education of the Filipino. The work is carried on not only in the schools from the primary through high schools and the university, but in all branches of the government. In other words the average Filipino has the same chance to show the stuff that is in him as the American boy.

The first effects of this plan of education was a movement away from the soil, but soon the competition for the "white suit jobs" became so keen and the pay so low that the young men graduating from the high school soon began seeking positions connected with agriculture and other industries. The agricultural college is one of the most popular schools of the university, and is yearly turning out a comparatively large number of students who, working as teachers of agriculture, as managers of plantations and as farmers, are doing much to improve the agricultural possibilities of the soil, bringing it nearer to its potential capacity. In its largest sense this is an experiment not so much in self-government as in teaching a tropical people to control tropical environment. Since the land is the part of the environment that is the chief source of wealth, each year finds it coming nearer to reaching its full productive capacity.

The writer did not realize the significance of the above until Dr. Treub, one-time director of the famous Buitenzorg Botanical Gardens and of the Agriculture Department of Java, made a visit to the Philippines. In conversation the writer asked him why he had come to the Philippines. He replied substantially as follows:

"Your publications showed me that the American government had made great progress in scientific development. Since coming I have found another thing. The attention you have given to the human element by your educational system has convinced me that you are on the right road to success. We, in Java, have developed our lands to as near their fullest capacity as the intelligence of the average native will permit. If we go farther we shall have to increase his efficiency by better education."

The experiment begun in the Philippines is not yet completed, but the results so far obtained show beyond a doubt that if fully carried out a great contribution will have been made in the increased efficiency of tropical people and tropical lands.

The space allowed for this article does not permit of the discussion of all the phases of the present utilization of tropical lands. There are two important primitive customs, however, that stand out above all others. The one has to do with the raising of agricultural crops, the other with the utilization of a natural crop, *viz.*, the virgin stands of timber ready to be cut. The economic significance of these two customs has generally been overlooked, and it is for this reason that they are emphasized above all others.

Primitive methods of farming, somewhat allied to those used in the stone age of man, still prevail over large areas in the tropics. Some one has defined a savage as one who depends entirely on the products of the soil and chase that nature provides without any effort on his part other than gathering his food. If this be accepted as the definition, few savages exist in tropical forest regions, for edible plant products are not found in sufficient quantities to sustain any considerable number of people for any length of time. In so far as the evidence goes it seems to be conclusive that farming was one of the earliest acquisitions of mankind. The power to increase the capacity of the soil to yield food was undoubtedly one of the greatest advances made by man in the control of his environment.

The method of farming generally in vogue to-day over large areas in the tropics consists of cutting a patch of forest, burning as much of the felled timber as practicable and then planting the crop and letting it shift for itself. Sometimes the same patch is used two or three years in succession, seldom more, and then the farmer migrates to a new patch and repeats the operation. Different degrees of cultivation of the crop prevail, from the most primitive, where no attempt to weed the crop is made, to the more advanced, where instruments such as the machete or hoe are used. The dividing line between this form of farming and that still more advanced is the use of the plow to prepare the soil for planting.

That the bulk of the staple foods in many tropical countries is raised on fresh virgin soils, that are abandoned temporarily or permanently after a short time, usually not more than three years, without the soil being touched by a plow, is one of the most significant economic problems connected with the present use of land in the tropics. Export figures alone of agricultural products for many tropical countries give a false impression concerning the use of the soil to yield produce, for statistics concerning the value of other products raised and consumed at home are either lacking or if obtainable are not given wide publicity. Thus the leading exports of the Philippines are Manila hemp, coconut products, sugar and tobacco. Yet a rough estimate of the value of all the raw agricultural products raised in these islands show that corn and rice, neither of which is exported, stand in the order named at the head of the list; in fact, they exceed in value all the other unprepared agricultural products of the country. Brazil is noted for its production of coffee, yet it is believed that if statistics were available the value of pastoral products would greatly exceed that of coffee; in fact, estimates of the 1914 productions of the state of Sao Paulo, where most of the exports of coffee originate, show that the annual productive value of pastoral products exceed those of coffee. It is not unlikely that if statistics for the whole of Brazil were available any one of the three principal agricultural crops of Brazil—corn, cassava and beans—would exceed in value the coffee crop.

The significance of this needs to be emphasized, for the bulk of the above-mentioned agricultural crops are raised on land that has never been plowed. Only restricted regions in the tropics are devoted to the so-called commercial tropical products like sugar, tobacco, rice, coffee, cacao and rubber, yet the staple foods that support the population of Central America and tropical South America are corn, cassava and beans, and the bulk of the farming population is engaged in raising these articles just as the majority of the farmers of the United States devote most of their attention to cotton, corn and wheat. In the one case a more primitive and migratory system of farming prevails, in the other the farming is more intensive and stabilized. Corn is one of the principal rations of a large proportion of the people of tropical America. If sufficient quantities of corn can be raised by the primitive methods above described to feed the 80 million people of Central and South American republics, what would be the per acre capacity of the land to raise this crop, were more intensive agricultural methods used? If the economic demand for this product should increase beyond the power of temperate lands to produce it in sufficient quantities, vast areas of arable tropical lands could be utilized to meet this

demand. The fact that under more intensive agricultural methods two crops can be raised annually means that the per acre capacity of tropical lands is double that of temperate lands.

The migratory farm described above begins to fill up with jungle growth even before it is abandoned. Eventually in the place of the virgin forest that formerly existed there arises a second growth jungle, with little economic value, almost entirely different in composition from the original forest.

If, in the early stages of the entrance of the jungle, the vegetation is burned, grasses rather than trees are favored. If, as often happens, the fires are repeated, grasslands are the result. In those parts of the tropics where the dry season is more pronounced, grasslands cover large areas where formerly valuable forests prevailed.

Migratory farming in the tropics has been so extensive that enormous areas originally containing heavy forests are now covered with second growth jungle or grasses. Just as one can travel for thousands of miles in temperate regions and see only patches here and there of the original forests, so one can journey through certain regions in tropical countries, along railroads, well-traveled horse or foot trails, and see little of anything else other than what O. Henry calls "amputated scenery." Indeed, if the density of population be taken into consideration, the destruction of the original vegetation of tropical countries is even more extensive than in temperate regions.

Originally the Philippines were practically covered with virgin forests from sea level, and in some places below high tide, to the tops of the highest mountains. To-day more than one half the area of the islands is covered with grasslands or second-growth jungle, most of which is the result of migratory farming begun in prehistoric times and continuing to-day where not controlled.

The observations of the writer and others in various parts of Mexico, Central America and South America show that the migratory farming is annually destroying large areas of the forests.

The tropical migratory system of farming is not practiced because the soil becomes exhausted, as some suppose, but because the farmer is unable to cope with the jungle growth that in a short time creeps into his farm. Strange as it may seem, it is easier for him to make a new farm than "weed" the old one. Either ignorant of the use of the plow, or, if he has such a knowledge, too poor to purchase one and the necessary work animal to go with it, he is forced to pursue the same method handed down to him by his more primitive ancestors. Usually, only when economic conditions force him by the scarcity of virgin forests on which to operate does he

make his farm in second, third or more, rather than in first growth forests. There is no doubt that the fresh soil of the burned virgin forest, improved by the ash constituents, yields better returns than other soils. This is not the reason why he prefers them, but because it is easier to cut and burn the virgin forests than to rid the soil of the much thicker second growth or grass, as the case may be.

Good, bad and indifferent soils prevail in the tropics as elsewhere. The migratory farmer's first consideration is not the quality of the soil, but one which has not yet been covered with thick jungle or grass with which he can not compete. Because he does not use the plow, steep slopes or poor soils with a virgin forest offer more favorable places for his operations than level ground or good soils without virgin forest.

There are a number of reasons why the average conception of the natural and commercial possibilities of the timber products of virgin tropical forests has been erroneous. Not the least of these is the fact that many observers who have written about them have visited those regions where the taller virgin forests of the lower elevations have almost entirely disappeared. The remnants that are left are on the upper slopes or near the tops of the high mountains where the conditions are not as favorable for forests of commercial value as the lower slopes. Such is in general the condition throughout the West Indies and in the more settled parts of other tropical countries. In such regions it is but natural that the capacity of the soil and climate to produce forest growth should be judged by the second-growth forests that are present rather than the original forest which has been destroyed. Again, just as we judge the kind of the agricultural products of tropical countries by the exports that reach temperate regions, so we have come to believe that the only kinds of timber that have value in tropical forests are those that reach our own markets, like mahogany, Spanish cedar, rosewood, teak and others that are used for special purposes and in small quantities when, as a matter of fact, where statistics are available, the quantity of the other woods used in tropical countries greatly exceeds those that are exported for our own use.

Wood is bulky and a large share of its final cost to the consumer represents transportation charges. Anything that will reduce transportation costs in this as in other products reduces the final cost to the consumer. Other things being equal, the nearer the forest is to the consuming center the cheaper the cost to the consumer. For this reason, as long as the virgin forests of temperate regions supply sufficient quantities of lumber, there is little or no need of obtaining it from far-away tropical regions. This is one

reason why tropical forests have contributed so little lumber to temperate regions. The little use of tropical woods to-day in temperate countries is not because tropical forests do not contain suitable woods for more general purposes, but because up to the present time the virgin forests of temperate regions have been able to furnish sufficient quantities to meet their own demands and because of the development of a well-organized lumber industry in the temperate regions that has furnished considerable quantities to tropical countries that are rich in forests but poor in lumber. Now that the easily accessible virgin forests of the temperate region have well-nigh disappeared, it is believed that the economic conditions are becoming ripe for the more extensive utilization of tropical woods.

Primitive methods of logging and lumbering as well as agriculture prevail throughout tropical countries. Such methods can be described as "tree" logging in contrast with "forest" logging of the United States and Canada. The crudest form of tree logging is where the log is dragged by hand to the place of consumption or to the nearest means of water transportation. The log may be hewn square or hand sawn where it is felled. In either case the bulk is reduced and can be transported easier. A step in advance is the use of animals for transporting round or squared logs or boards. The introduction of steam for transporting logs from the forest to the mill for sawing and all devices for handling the finished product made possible "forest" or industrial logging. While the more primitive methods are still best suited to certain classes of forest, especially those with small trees, those covering small areas and where only a few of the many species in the forest are of commercial value, such methods are inadequate to furnish timber in great quantities; consequently, tropical countries rich in forests have generally been poor in lumber and have depended on the products of industrial logging of the temperate regions in part at least.

It has long been contended by some that tropical forests are not adapted to industrial logging. This contention has been due to the erroneous belief, as stated above, that of the many species that make up tropical forests only a few can have commercial value. Tropical hardwood forests contain more tree species per acre than do those of temperate regions. Census of tree species of the Philippines show 80 to 100 species per acre. The estimated number of tree species in the Philippines (120,000 square miles) is 2,600 or about three times as many as in North America, north of Mexico. The hardwood forests of other tropical countries would show similar conditions. While this fact is interesting from a botanical

standpoint it gives a false idea of the commercial importance of the forests. A rough estimate of the standing saw timber of the Philippines is 200 billion board feet; of this 150 billion board feet belong to one family composed of 60 or more tree species. Of these some 12 or 15 tree species form the bulk of the timber. Moreover, the wood of all the members of this important family of trees can be grouped into three classes, *viz.*, comparatively light hardwoods, not durable in contact with the ground, but as easily worked and as durable as pine, that are used for light construction work. They are estimated to comprise about half the standing timber of the Philippines. The second group of woods are moderately hard that are used for heavier construction work not in contact with the ground, and comprise perhaps 40 billion feet of the standing timber. The third group are hard, heavy and durable timbers and are used mostly for construction work where great durability is required. The primitive methods of logging used in the Philippines previous to American occupation were unable to supply the demand for lumber caused by the awakened industrial development that followed. An examination of the forests showed that they were suitable for industrial logging and milling. As a result such methods were introduced and not only was the increased demand met, but sufficient quantities were produced to allow the beginnings of a comparatively large export trade.

The writer has attempted to show that, due to the full-time working of nature's chemical laboratory, the good old mother earth of tropical regions is able to store up two or more times as much energy annually in the form of useful plant products as are temperate regions, and that, while to-day primitive methods prevail in the utilization of these products, each year economic pressure proceeding mainly southward from the more progressive temperate nations to the north is forcing the better utilization of the soil. The economic penetration of the white man into the tropics in search of raw materials is forcing him to better control the environment that is new to him, both to enable him to live there and to protect the nations from which he comes from the diseases that find a more favorable environment there. Civilized temperate man has made great strides in controlling the environment in which he lives. He has built and heated houses to control the rigors of winter. He has invented means of rapid transportation that will take him to cooler climates in summer and warmer climates in winter. Is it too much to expect that eventually he will be able to construct homes in the tropics that can be cooled to the proper degree of thermal conditions? Also in most parts of the tropics cool highlands that offer favorable places for recuperation are within easy reach of the more

torrid heat of the low altitudes. With air transportation better developed, truly temperate highland tropics will be easily accessible.

Attention has been called to the possibilities of increasing the all-round efficiency of tropical people as illustrated by the educational experiment now going on in the Philippines. While independent tropical nations can not be directly improved in this way, yet the indirect influence of temperate culture on these nations is not inconsiderable. It is felt by the example of temperate colonists that are reaching some of these countries in increasing quantities, by the increasing numbers of young men and women who finish their education in the schools of the United States and European nations, by industrial organizations of temperate nations operating in them, and by the work of such organizations as the Rockefeller Institute and others.

HOT WAVES, HOT WINDS AND CHINOOK WINDS IN THE UNITED STATES

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I. Hot Waves

Introduction.—Spells of excessively hot weather, occurring at irregular intervals and lasting for varying periods of time, are characteristic of the summers of the central and eastern United States, especially of the great Mississippi lowland, of the Ohio Valley region, and eastward even to the immediate Atlantic coast. Such periods of extreme heat, known as hot waves, warm waves, hot spells or heated terms, are the antithesis of the cold waves of winter. Both are typical American phenomena. Both are associated with certain well-defined pressure-types. Both have many critical physiological and economic effects. Both are developed to a remarkable degree of intensity and frequency in the eastern United States. Both need consideration in any discussion of United States climatology.[1]

Definition of a Hot Wave

Any spell of uncomfortably hot weather in late spring, summer or early autumn lasting more than a day or so is likely to be popularly spoken of as a hot wave. The longer the hot weather lasts and the more excessive the heat, the more fully is it thought to

[1] Reference may here be made to the following general discussions of hot waves: Burrows, Alvin T.: "Hot Waves," *Yearbook U. S. Dept. of Agriculture for 1900*, 8vo, Washington, D. C., 1901, pp. 325–336, with charts; Henry, Alfred J.: "Climatology of the United States," *U. S. Weather Bureau Bulletin Q*, 4to, Washington, D. C., 1906; "Weather Forecasting in the United States," by a Board composed of Alfred J. Henry, Edward H. Bowie, Henry J. Cox and Harry C. Frankenfield. *U. S. Weather Bureau No. 583*, 8vo, Washington, D. C., 1916, pp. 370, Figs. 199 (p. 290, and elsewhere, on hot waves). There have been numerous discussions of the conditions and characteristics of individual hot waves, among which the following may be mentioned: Garriott, E. B.: "The warm waves of July and August, 1892; *Month. Wea. Rev.*, Vol. 20, 1892, pp. 223–224; Phillips, W. F. R.: "Sunstroke weather of August, 1896," *ibid.*, Vol. 24, 1896, pp. 409–413; "The hot wave of July, 1898," *ibid.*, Vol. 26, July, 1898 (with charts VIII–XII); Henry, Alfred J.: "The hot weather of August, 1900," *ibid.*, Vol. 28, 1900, pp. 333–336 (also contains useful general information on hot waves); *idem*: "Hot spell of August, 1918," *ibid.*, Vol. 46, 1918, pp. 361–363.

deserve the name. There has never been an official definition of a hot wave by the United States Weather Bureau, as in the case of a cold wave. According to Burrows, a hot wave is a period of three or more consecutive days on which the maximum temperatures reach or exceed 90°.[2] This may perhaps serve well as a rigid limitation for meteorological use, but in the present discussion, which concerns the larger characteristics and relations of hot spells from their climatic viewpoint, no such clean-cut definition is necessary.

General Description of a Hot Wave in the Eastern United States

As a weak cyclonic depression moves slowly eastward across the northern tier of states, usually over the Great Lakes and down the St. Lawrence Valley, the southerly and southwesterly winds that prevail in front of it, coming from warmer latitudes, bring very high temperatures, accompanied by high humidity and generally hazy skies. In the absence of an extended cloud cover, the normal diurnal variation of temperature, under the high and powerful summer sun, may carry the thermometer well up into the 90's, and even to 100° or over in the early afternoon hours. The night in a typical hot wave is likely to bring comparatively little relief, except in the mountains and on the coast. The importation of heat from warm southern latitudes continues with the northward drift of the air while the sun is below the horizon, and nocturnal radiation is reduced in the presence of the large amount of water vapor in the atmosphere.

In the typical cold wave the fall in temperature comes with great rapidity, as the wind shifts from southerly to westerly and northwesterly on the wind-shift line at the rear of the retreating cyclonic storm. The cold wind arrives as a sudden blast, at high velocity, and gradually dies down after a day or two. In the case of the American *sirocco,* as the hot wave might well be called after its well-known Italian counterpart, the southerly wind is apt to begin very gently; gradually increases its velocity and brings higher and higher temperatures as the gradients become steeper with the gradual approach of the depression. It is thus characteristic of hot waves that the maximum and the minimum temperatures may both become higher on two or three or more successive days.

Fig. 1 is a reproduction of the thermograph and barograph records at a New England station during a very short hot wave. It illustrates, within five days, conditions preceding, accompanying and following a brief spell of very hot weather in that district. The record begins with moderate temperatures under cloudy skies and easterly winds coming from the Atlantic. The change of wind

[2] Burrows, A. T., *loc. cit.*

to southwest, with the slow eastward drift of an ill-defined summer cyclonic depression, brings a marked diurnal range of temperature under prevailingly fair or clear skies. The temperature belt (enclosed by broken lines) rises as a whole, under cyclonic control, to a high maximum (June 23), which is clearly the result of imported heat plus local warming under sunshine. The high nocturnal tem-

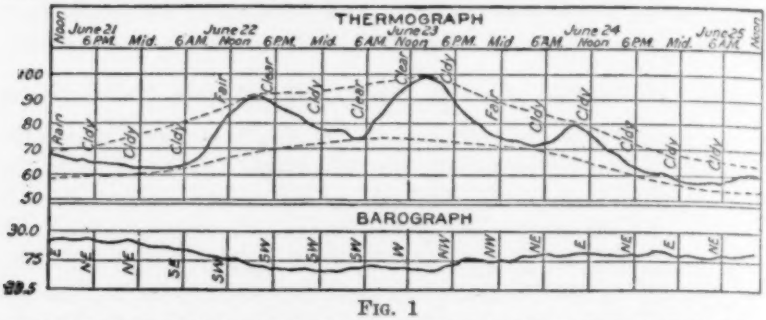

FIG. 1

Typical Instrumental Record during a Hot Wave in the Eastern United States.

peratures (June 22–23) are characteristic. With a shift of wind to the northwest a general fall in temperature takes place. In the case of this particular occurrence, northeast and east winds quickly followed, bringing small diurnal ranges under cloudy skies, the temperatures falling as a whole. The low noon maximum on June 25 is due to these cool northeast winds and clouds. Cool spells of this kind near the coast afford welcome relief after the high temperatures of a preceding hot wave.

A sluggish movement, even at times an almost complete stagnation, of the pressure-conditions is a feature of great importance in the summer weather types of the eastern United States, and accounts for the fact that hot waves sometimes last over the central portions of the country for two or even three weeks with little or no relief in temperature or change in general weather conditions. Two, or even more, hot waves may come in succession with hardly a break between them. On the other hand, such hot spells may last two or three days only. They do not recur with any regularity, but in eastern sections there is often, for a time, a sort of sequence of summer weather types, consisting of a hot spell of two or more days, followed by a cooler period of about the same length, and then by another hot spell. Such a series depends upon a certain temporary regularity in the succession of summer cyclonic depressions drifting eastward across the northern tier of states. At best one severe hot wave may be expected every summer, and occasional summers have many extremely hot spells.

It is characteristic of a severe and prolonged hot wave, which may cover as much as one half of the United States, that it is ac-

companied by a protracted drought. Such precipitation as occurs is in the form of sporadic "heat" thunder-showers, which are usually local, afford temporary relief only and do not benefit large areas. The excessive heat combined with the drought constitutes the unfavorable feature for crops. The eastward movement of the cyclonic centre eventually brings a shift of the wind from southerly and southwesterly to westerly and northwesterly, often accompanied by a series of severe wind-shift line thunderstorms. Then comes the summer cool wave, with its brisk northwesterly winds, its bright blue skies and the welcome relief of its refreshingly lower temperatures. At other times, a general cyclonic rain may terminate the hot wave, followed by the shift of the wind to west and northwest.

Hot waves are to be looked for in the months from June to September. They are as a rule most frequent and most intense in July, but August and September do not lag far behind and are not infrequently characterized by hot waves of great intensity. Indeed, uncomfortably warm spells of a few days' duration, with southerly siroceo winds, occur as early as May, even in New England.

Hot Wave Characteristics in Different Sections of the Eastern United States

As has been pointed out by Burrows, hot waves differ a good deal in different sections of the eastern United States. Over the Great Plains a hot wave not only brings very high maximum temperatures but is often accompanied by special local "hot winds," which are likely to cause serious damage to growing crops. The relative humidity over the plains is less than in eastern sections, and the diurnal range somewhat greater. Hence the oppressiveness of the high temperatures is lessened, and the nocturnal cooling gives a certain amount of relief during the night. East of the plains, as a whole, the maximum temperatures are generally lower, but owing to the higher relative humidity the sensible temperatures are higher and the discomfort and suffering are greater. The hot nights, with minima often over 70°, are especially uncomfortable. Over the Mississippi and Ohio valleys, and eastward to the Atlantic coast, much suffering and illness result, especially in the crowded districts of the large cities, from the prolonged hot spells which occasionally prevail for a week or two at a time. The northeastern section of the United States, including the Great Lakes, has the advantage of being near the most-frequented paths of the weak cyclonic depressions of summer, and therefore of being reached by the cool northwesterly winds on the rear of these disturbances. Because of the small size and slight development of most of these lows, the cool

waves which follow them usually can not advance far to the south, but are able to break the hot spell over the northern sections which are reached by the cool northwesterly winds. Along the Atlantic coast and the shores of the Great Lakes, the cooling effect of the ocean and lake waters, whenever a cyclonic wind or a sea or lake breeze blows onshore, serves to break the monotony and the continuity of many a hot wave which in interior districts may last for days without a break. Further, the northeastern section has the relief afforded by the occasional cloud sheets of the weak cyclonic depressions which drift eastward across the Great Lakes and down the St. Lawrence valley, either with or without general rains (see Fig. 1).

The southern states have a somewhat different relation to hot waves. They naturally have prevailingly higher summer temperatures. They are farther from the storm tracks. Yet when conditions are favorable they do not escape. Often, however, while warm southerly and southwesterly winds are giving hot wave conditions over the central and northern sections, northerly and northeasterly winds are blowing across Florida and the northern Gulf coast. Florida, with its winds coming from the Atlantic, may then have decidedly lower temperatures than states much farther north. Some years ago, the writer was in northern New England during a severe July hot wave. Even in the New Hampshire mountains the maxima reached 90°, and the nights were uncomfortably warm. A correspondent in Orlando, Florida, wrote as follows of the weather conditions there: "From all I could see in the newspapers, we had about the coolest place in the country down here. It is about 35 miles to the Atlantic Ocean and about 65 miles to the Gulf, and we have a delightful breeze most of the time. After supper, we put on wraps and sit on our front porch, and are comfortable with them on."

Some Economic and Physiological Aspects of Hot Waves

The combination of excessive heat and of a desiccating drought, if prolonged over several days, naturally results in serious damage to crops which may extend over wide areas. If such a hot wave comes at an especially critical period in the life of a staple crop, the financial loss may be much greater than that caused by a severe hurricane. It is not alone the accompanying drought which works the injury to growing plants. The baking effect of the high temperatures is in itself disastrous. Beneficial rains within a reasonable time may at least partly make good the injury caused by the drought, but the damage due to the heat may be permanent. Not only is the yield reduced in quantity, but the quality of the crop

is inferior. A few hot spells, even if not greatly prolonged, may reduce the local yield in a summer of normal heat as much as 20 or 25 per cent. Fortunately, however, hot waves are not often equally severe over extended areas. Hence, while the damage in one state or one section may be considerable, other sections escape the worst effects.

Burrows has pointed out that the effects of hot waves as a general rule differ a good deal according to the time at which they come.[3] Thus June hot waves are naturally usually less frequent and less intense than those of mid- and late summer. Furthermore, the normal type of rainfall distribution gives a June maximum over a large area of the great agricultural districts of the west—the so-called "Missouri type" of rainfall. Hence, many cereals, like corn, *e.g.*, are often benefited by high temperatures early in the summer. On the other hand, fruits which ripen in June are often seriously harmed. Crops maturing in the autumn are most liable to be permanently injured by hot waves in July and August. Not only is the heat likely to be greatest then, but the normal season of maximum rainfall has passed, and the scattering and sporadic thundershowers which bring most of such precipitation as occurs are quickly over; do not cool the air effectively or for long, and are soon followed by strong sunshine and active evaporation. Moreover, mid-summer is a very critical time for many cereals. Indian corn may be withered by the excessive heat and its growth checked beyond the possibility of later recovery. In the south, a severe hot wave at this season is liable to cause very serious injury to the cotton crop. Pasture grass may be so burned and withered as to be practically useless for feed.

September hot waves, as suggested by Burrows, are likely to drive some standing crops to maturity too quickly, but may, on occasions, help to ripen a backward crop.

An interesting train of economic effects accompanies any prolonged hot wave. A study of the effects associated with the heat and drought of July, 1901, was made by the writer some years ago, and illustrates the variety of economic aspects associated with this type of weather.[4] There was a marked increase in the demand for light-weight summer clothing of all kinds and of vacation supplies. The retail stores quickly sold out their stocks and sent in re-orders to the wholesalers. Thousands of people, suffering from the heat in the large eastern cities, filled trains and steamers on their way to

[3] Burrows, A. T., *loc. cit.*

[4] Ward, R. DeC.: "Some economic aspects of the heat and drought of July, 1901, in the United States," *Bull. Amer. Geogr. Soc.*, Vol. 33, 1901, pp. 338–347.

cooler summer resorts, on the coast and in the mountains. Hotels and boarding-houses were crowded. The demand for ice and for all kinds of cooling summer beverages was tremendous. In order to save themselves the discomfort of shopping, customers sent in their orders by mail, and the large city stores were unable in many cases to keep up with their correspondence, and had to engage extra clerks to handle it. The stock markets responded in a very striking way to the weather conditions. Not only were the prices of wheat, corn and other cereals markedly affected, but so also were the stocks of the great cereal-carrying railroads. So sensitive to weather conditions are the stock markets that the prospect or the occurrence of even light showers in any portion of the hot wave area was immediately reflected in higher quotations. The lack of water and of pasturage and the inevitable future high prices of corn led western cattlemen to ship their cattle to market in immense numbers. The result was that the prices of cattle on the hoof, of meat and of hides dropped, and the great packing houses were practically able to dictate their own terms. There was a greatly decreased market demand for meat, and an increased demand for fresh vegetables, so great that the supply was wholly inadequate and in many cities the available stocks of canned vegetables were sold out to meet the needs of customers. The settlement of a strike in some of the Pennsylvania steel mills was delayed because the operatives did not want to go back to work as long as the terrific heat lasted. In many cases manufacturing and industrial plants shut down, and large wholesale and retail concerns in the cities shortened the hours of work in order to give their employees a rest.

Such were some of the more obvious economic effects of one severe and prolonged hot spell. Similar conditions, varying with the locality, with the extent and severity of the heat, and with other factors, may be looked for in any well-marked hot wave.

The physiological effects of hot waves are none the less striking. The high maximum temperatures, the hot nights and, in eastern sections, the high relative humidity at times combine to render the conditions almost insupportable, especially in the crowded districts of the great cities. Heat prostrations, sunstroke and other immediate and direct consequences of the excessive and uniform heat and humidity are common. The number of deaths, and especially those of infants and young children from cholera infantum, may become appallingly large. A study of the physiological effects of one prolonged and severe hot spell which occurred over two thirds of the eastern United States at the end of July and in the first part of August, 1896, by Dr. W. F. R. Phillips, is the only intensive inves-

tigation of this kind available.[5] Dr. Phillips finds that during the three weeks ending August 22, 1896, 2,036 known deaths were directly due to sunstroke, and the list was doubtless far from complete. Probably more than 12,000 cases of varying degrees of severity actually occurred. The significant term "sunstroke weather" has been suggested by Dr. Phillips as being appropriate for an especially fatal period during this long hot spell which he studied. As to the direct meteorological cause of sunstroke, the author concludes that neither absolute nor relative humidity are as important as the value of the maximum temperature. He believes that sunstrokes do not occur until the temperature is well above that to which people are accustomed, regardless of other atmospheric conditions. Each locality "has for its native or acclimated inhabitant a special local sunstroke temperature or range of temperature." As a "working hypothesis" it is suggested that "sunstroke becomes imminent during the summer months when the mean temperature of any one day or of several consecutive days becomes equal or nearly equal to the normal maximum temperature for the same period." Or, differently expressed, "the liability to sunstroke increases in proportion as the mean temperature of the day approaches the normal maximum temperature for that day."

Dr. Phillips' conclusions have not been unchallenged. His paper was discussed at a meeting of the American Climatological Association, where it was pointed out that one or two days of high maximum temperatures are less effective in causing sunstroke than continuously high temperatures both day and night for at least two days.[6] Henry has pointed out that serious discomfort is seldom felt unless the night temperature remains above 75°.[7] This value, however, probably varies slightly with the locality, being somewhat lower for New England (70°–72°). It has also been pointed out by others that the absence or at any rate great infrequency of sunstrokes in the southwest, where the maximum and the mean temperatures are much higher, militates against Dr. Phillips' views.

Weather Map Conditions Favorable to Hot Waves in the Eastern United States

The weather map types which produce hot waves are just the opposite of those which produce cold waves. The former generally bring the maximum heat on the northern and western outskirts of

[5] Phillips, W. F. R., *loc. cit.*

[6] *Trans. Amer. Cli. Assoc.*, Vol. 13, pp. 234–237.

[7] Henry, Alfred J., *Ann. Rept. Chief of Weather Bureau for 1897*, 4to, Washington, D. C., 1898, p. 264. Also, "Climatology of the United States," pp. 39–45.

an anticyclone, while the cold wave area is to the south and east. Hot waves occur on barometric gradients sloping northward, the high pressure area being over the southeastern United States and the depression in the north or northwest. In cold waves the high is in the northwest or north and the low is to the south or east. The gradient system is thus essentially reversed in the two cases.

As in the case of cold waves, the weather maps which illustrate hot wave conditions differ a good deal from one another in details, and many type maps could be given as illustrations. The essential

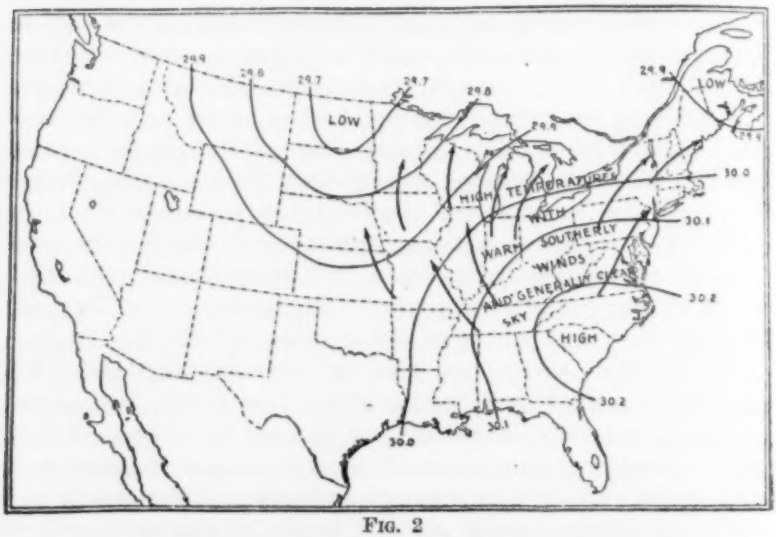

FIG. 2

Hot Wave Type Map for the Eastern United States.

and fundamental condition may, however, be shown in a broadly generalized map, Fig. 2. This map is not a copy of any single daily weather map, but is drawn free-hand to represent a general pressure-distribution which is favorable to the occurrence of hot wave conditions over the eastern United States. The characteristic features are an anticyclonic area over the southeastern states and a moderate depression over the upper Missouri-Mississippi Valley region or the upper lakes. For the production of a prolonged and intense hot wave, this general distribution of pressure must continue, without much change, for a good many days. In other words, there is a sort of slackening up or relative stagnation of the general circulation of the atmosphere. The regular eastward movement of low pressure areas along the northern border is somehow checked, and a general condition of low pressure persists for days over the northwestern, middle western or northern states, instead of the more normal condition of an eastward drift of a series of cyclonic

and anticyclonic areas, with shifting winds and showers or occasional thunderstorms. The southeastern high pressure area, which is really the western margin of the great tropical high pressure belt of the North Atlantic Ocean, also persists, with essentially no interruption or change for days, and seems to act as a barrier to the eastward movement of the cyclonic depression to the north of it. In this type of map, a great flow of warm, southerly winds covers the interior valleys and most of the Atlantic coast. With the slow eastward drifting of a low pressure area across the lakes and thence down the St. Lawrence Valley, conditions are favorable for the occurrence of a hot wave well into the northeastern states, and along the Atlantic coast as far as New England. On the other hand, the persistence of the low pressure condition in the northwest favors the occurrence of a hot wave over all the great central valleys. With the eastward movement of the northern cyclonic depression and the disintegration of the southern anticyclone, the hot wave conditions come to an end.

Sources of Heat in a Hot Wave

The excessive heat of a hot wave is due to a combination of several factors. Among these are (1) the importation of air from southern latitudes, (2) effective cumulative warming of the earth's surface and of the lower layers of the atmosphere to a greater height than usual under the strong summer sun, day after day, unhindered by any general cloud-cover, the diurnal heating being in excess of the cooling by nocturnal radiation, and (3) a certain amount of dynamic heating of the descending air under the anticyclone. The cumulative effect of these various contributing causes, when continued for several days, is such that, as Professor Henry has put it, a greater impulse than usual is necessary to put an end to the existing conditions and bring about cooler weather.

Hot Waves in other Parts of the United States

In the preceding discussion, reference has been made only to the hot waves of the broad region east of the Rocky Mountains. These are the most extended and most striking phenomena of the kind in the United States. Yet hot spells are by no means unknown elsewhere, although the conditions of their occurrence and their characteristics are different. It often happens that while a severe and prolonged hot wave is prevailing over the eastern section of the country, other sections, such as the Plateau or the Pacific coast, are abnormally cool. The western mountain and plateau districts have the advantage of active nocturnal radiation in the dry air and under the clear skies of those elevated areas, so that, even when the

days are very hot, the nights are characteristically cool. Long periods of high temperature are, however, normal summer conditions over the less elevated portions of the Plateau Province, and the summer "heat island" of North America centres over the southern portion of this district. The Pacific coast is exempt from the severe and prolonged hot waves which characterize the eastern United States, but occasional short spells of uncomfortable heat occur even on the coast, although the prevalence of onshore winds from the Pacific most of the time ensures this coastal belt unusually cool and temperate summers. The interior valley of California, however, which is well shut off from ocean influences throughout nearly its whole extent, has very hot and dry summers, especially in the south. The conditions are especially uncomfortable when an occasional hot north wind blows. Locally, this wind is not only unusually hot, but also dry and dust-laden and becomes very disagreeable and trying. This Californian "norther" is discussed in the following section on hot winds.

II. Hot Winds[8]

Description of "Hot Winds"

Reference has been made above to the occasional occurrence, during summer hot waves on the Great Plains, of so-called "hot winds." These are a definite feature of the climate of the eastern slope of the Rocky Mountains. They are a special local development of abnormally hot currents of air within a general flow of hot winds covering a large area. Popularly, the term "hot winds of the plains" has come into use because of the occurrence of these local superheated currents chiefly over the Great Plains region, between the eastern Rocky Mountain foothills and the Mississippi River, and mostly between latitudes 34° and 45° N. They are especially well known in the drier, western parts of the plains. In much less marked development they have been reported as far east

[8] The following references are the most important discussions of hot winds. Most of what here follows is based upon them. Curtis, George E.: "The hot winds of the plains," *7th Biennial Rept. Kansas State Board of Agric.*, Dec., 1890 (contains descriptions of numerous occurrences, and includes weather maps showing hot wave conditions; period covered 1880–1889); Cline, Isaac M.: "Hot winds in Texas, May 29 and 30, 1892," *Amer. Met. Journ.*, Vol. 9, 1892–93, pp. 437–443; *idem*, "Summer hot winds on the Great Plains," *Bull. Phil. Soc. Wash.*, Vol. 12, Jan., 1894, pp. 309–348 (collection of all cases recorded since 1870, illustrated by three typical hot wind maps; also discussion of causes); reprinted in part in *Amer. Met. Journ.*, Vol. 11, 1893–94, pp. 175–176; Henry, Alfred J.: "Climatology of the United States," *Bull. Q, U. S. Weather Bureau*, 4to, 1906, pp. 56–57. Numerous cases of individual occurrences of hot winds are described in the *Monthly Weather Review*.

as Illinois, Wisconsin, Indiana, Michigan and Ohio. The hot winds of Kansas and Texas have been most often described and most thoroughly observed and studied.

The chief characteristics of hot winds are their intense heat and their extreme dryness. They come in narrow bands of excessively hot winds, ranging from perhaps 100 feet to a half mile or so in width, in a general hot spell, with intermediate belts, varying from a few yards to a few miles in width, of somewhat less terrific heat between them. Hot winds usually last only a few hours, but may recur in rapid succession in the same general locality and have a habit of coming in groups, thus perhaps affecting a territory of a few hundred acres. At times, an extended development of hot wind conditions may bring them here and there over a much larger area, embracing most of a state, or even portions of two or three states. Their direction is usually southwesterly or southerly, but occasionally they blow from the southeast and even from the north. Their velocity varies from a gentle breeze to a gale, and they are diurnal in their occurrence, usually dying down toward sunset. The winds may continue to blow throughout the night, but the temperature is then generally lower and more endurable. Very hot nights are, however, by no means unknown. It has been reported in one case that people woke up in the night and thought their houses were on fire. July and August bring most of the hot winds, but they also occur before June and into September.

The dry withering heat in a true hot wind has been compared by many observers to the blast from a hot furnace. Temperatures of 100° to 110°, and even higher, are recorded in the shade. On one occasion the temperature rose 7° in 10 minutes on the setting in of a hot wind. The Weather Bureau observer at Leavenworth, Kansas, reported as follows during a hot wind: "At 1 P. M. a very hot and extremely dry wind set in from the southwest, feeling as a hot blast from a furnace. It caused the thermometer to rise rapidly, attaining a maximum of 101° at 4 P. M. and the humidity dropped suddenly to 17 per cent. This hot wind continued until sundown. It withered and almost burned vegetation and caused a total suspension of outdoor labor during the afternoon."[9] Another observer, at Lawrence, Kansas, reported that the air was excessively dry. The relative humidity fell to 7 per cent. The nights following three days of hot winds were, however, "comparatively cool" (minima 65°–66°). A brief summary of the official meteorological record during the hot winds in Eastern Kansas on September 12, 1882, is given by Henry.[10] Although ordinary psychrometer read-

[9] Quoted by A. J. Henry, *loc. cit.*

[10] *loc. cit.*

ings are by no means accurate, especially when the air is excessively dry, there is no doubt that the percentage of relative humidity falls to 20 per cent., or even less.

Economic and Physiological Aspects of Hot Winds

The excessive heat and dryness of these hot winds, which usually blow with considerable velocity, make them very injurious to all crops. They are veritable scourges, but fortunately do not occur often in their greatest severity. Not only is moisture evaporated from the soil, but growing vegetation is literally dried out as it stands. If the hot winds happen to come at a critical period in the growth of a crop, they may cause heavy damage within a few hours. In one case of recurring hot winds in Kansas some years ago, over 10,000,000 bushels of corn were ruined, and the crop was reduced by 10,000,000 more. Vegetation withers; leaves crumble to dust at the touch; corn, wheat and other cereals look as if they had been scorched by fire; apples are described as being baked while hanging on the trees. So destructive are these winds that during the summer, when the harvest is in a critical stage, reports of hot winds in the west are at once reflected in the future price of wheat, corn and other crops on the exchanges. The moister the soil, as a rule, the less destructive is the hot wind. Therefore, any method of conserving soil-moisture tends to lessen the damage. Further, as evaporation depends largely upon the velocity of the wind, wind-breaks, by decreasing the velocity and helping to increase the resistant powers of the soil, are an additional means of protection (Henry).

A case is on record, on the Southern Pacific Railway in Texas, when during severe hot winds the rails expanded to such an extent that they "sprung," and traffic had to be suspended until the rails were shortened and replaced.

If hot wind conditions continue for several days, great suffering to human beings and to animals in the intensely hot, dry air results. The skin becomes dry and parched. One observer, in Texas, reported of the hot winds of May 29–30, 1892, "these hot currents would almost stop one's breathing. I was caught in the centre of one about 100 feet in width, and it was almost insufferable."[11] The dry heat tends to excessive irritability and nervousness in many cases, insomnia being a frequent result. A correspondent writes from western Kansas during a late June hot wave: "We have had no rain for several weeks, with daily temperatures in the 90's and a low humidity. For the last several days I have had my first experience of the 'hot winds.' To-day the furniture in my room is cracking in the dry air. I believe, from my own experience, what

[11] Quoted by I. M. Cline. See *Amer. Met. Journ.*, Vol. 9, 1892–93, pp. 437–443.

I formerly doubted, that this dry air inclines to nervousness. Although very tired at night and entirely normal, I often can not get to sleep for an hour or more. And this, for me, is insomnia."

Weather Map Conditions Favorable for Hot Winds

Most hot winds occur with anticyclonic conditions over the southeast and low pressures over the Dakotas, the pressures decreasing northward and northwestward into Canada and the depression being nearly stationary or moving slowly along the eastern Rocky Mountain slope and eastward. Under these conditions, the general winds over the plains are southerly and southwesterly, the velocity being greater the steeper the gradient. Occasionally the depression develops over the eastern slope of the Rocky Mountains, and usually there is a trough or V-formation elongated towards the south and southwest from the northern low. Hot winds are also associated with secondary cyclones at the southern extremity of V-shaped depressions which are traveling eastward along the northern boundary of the United States. In view of these relations to low pressure systems, it is natural that hot wind conditions should gradually move eastward with the eastward progression of the general pressure distribution upon which they depend. In connection with any attempt to study the weather map conditions of hot wind occurrence, it must be remembered that the maps present the facts at one moment only (8 A. M., Eastern Standard Time), in each 24 hour interval. The wind directions and the temperatures shown on the maps at the various stations are therefore unlikely to be those observed while the hot winds were blowing at those stations.

Cause of the Excessive Heat and Dryness of Hot Winds

There has been a good deal of discussion as to the fundamental cause of the extreme heat and the very low relative humidity characteristic of the true "hot winds" of the plains. One group of writers, among whom are Professor W. M. Davis[12] and Dr. I. M. Cline,[13] holds that these winds have a special and peculiar intensity of heat and dryness which distinguishes them from the general hot wave in which they occur. This characteristic is attributed not simply to the heat imported by the horizontal flow of the warm, southerly winds but to the presence of descending currents from a considerable height, starting at fairly high temperatures and then warmed adiabatically by compression during their descent. In

[12] Davis, William Morris: "Elementary Meteorology," 8vo, Boston, 1894, p. 233.

[13] Cline, I. M., *loc. cit.*

other words, they are somewhat similar to *chinook* or *foehn* winds. There are difficulties in accepting this theory, for it is not easy to see how such superheated, and therefore light, local currents of air can be forced down, over extended level plains, into a general body of air which is cooler, and therefore heavier, than they are. If the initial downward impulse is present, it is conceivable that the momentum of the descending air may be sufficient to carry the "hot wind" currents below the level of their equilibrium. As evidence of such dynamic heating, it has been pointed out that there have been numerous cases in which the temperature was lower and the humidity higher over the districts to the south of the hot wind area, and that hot winds have occurred at night and after rain. It would therefore seem as if local surface warming of the air in a hot wind could not fully account for the heat and dryness. Dr. Cline believes that the dry air, which has been dynamically heated, is carried forward aloft faster than below, and descends here and there through moister and less dense air below, which rises and forms the scattering clouds often observed.

The second group of writers, among whom are Professor A. J. Henry and the late George E. Curtis, holds that the local heating of the dry earth's surface under clear skies and intense insolation is a sufficient explanation of the heat and dryness of the hot winds. It is pointed out that hot winds do not occur when the soil is moist; that rains quickly bring them to an end, and that they are essentially diurnal phenomena. Favorable local conditions, both of temperature and of moisture, doubtless play a part.

The question, which of these two views is the correct one, need not be debated here. More complete observations of these interesting phenomena, and especially more data from the free air, will in time lead to a fuller understanding.

It is clear that hot winds will always continue to be a serious climatic handicap over the districts in which they occur. Perhaps, eventually, with improved methods of conserving soil moisture and with the planting of windbreaks, some of the blighting effects of these winds upon growing crops will be somewhat mitigated.

III. Chinook Winds[14]

Description of a Chinook Wind

Picture to yourself a wild waste of snow, wind-beaten and blizzard-furrowed until the vast expanse resembles a billowy white sea. The frigid air, blowing half a gale, is filled with needle-like snow and ice crystals which sting

[14] In addition to the brief discussions in the meteorological text-books, reference may be made to the following for further details: Harrington, Mark W.: "The chinook winds," *Amer. Met. Journ.*, Vol. 3, 1886–87, pp. 330–338, 467–475, 576–523; Hazen, Henry A.: "Chinook winds," *Month. Wea. Rev.*,

the flesh like the bites of poisonous insects, and sift through the finest crevices. . . . Great herds of range cattle, which roam at will and thrive on the nutritious grasses indigenous to the northern slope, wander aimlessly here and there, or more frequently drift with the wind in vain attempts to find food and shelter; moaning in distress from cold and hunger, their noses hung with bloody icicles, their legs galled and bleeding from breaking the hard snow crust as they travel. . . . Would the chinook never come? The wind veered and backed, now howling as if in derision, and anon becoming calm, as if in contemplation of the desolation on the face of nature, while the poor dumb animals continued their ceaseless tramp, crying with pain and starvation. At last, on December 1, at about the hour of sunset, there was a change which experienced plainsmen interpreted as favorable to the coming of the warm southwest wind. At sunset the temperature was only —13°, the air scarcely in motion, but occasionally seemed to descend from overhead. Over the mountains in the southwest a great bank of black clouds hung, dark and awesome, whose wide expanse was unbroken by line or break; only at the upper edge, the curled and serrated cloud, blown into tatters by wind, was seen to be the advance courier of the long-prayed-for chinook. How eagerly we watched its approach! How we strained our hearing for the first welcome sigh of the gentle breath! But it was not until 11.35 P. M. that the first influence was felt. First, a puff of heat, summer-like in comparison with what had existed for two weeks, and we run to our instrument shelter to observe the temperature. Up goes the mercury, 34° in seven minutes. Now the wind has come with a 25-mile velocity. Now the cattle stop travelling, and with muzzles turned toward the wind, low with satisfaction. Weary with two weeks standing on their feet they lie down in the snow, for they know that their salvation has come: that now their bodies will not freeze to the ground.

The wind increases in strength and warmth; it blows now in one steady roar; the temperature has risen to 38°; the great expanse of snow 30 inches deep on a level is becoming damp and honeycombed by the hot wind.

Twelve hours afterward there are bare, brown hills everywhere; the plains are covered with floods of water. In a few days the wind will evaporate the moisture, and the roads will be dry and hard. Were it not for the chinook winds the northern slope country would not be habitable, nor could domestic animals survive the winters.[15]

There have been many general accounts of chinook winds in the United States, but few, if any, first-hand descriptions have been printed as vivid, as complete and as accurate as the one just quoted, written by the Voluntary Observer of the Weather Bureau at Kip, Montana, after a well-marked occurrence of this phenomenon in November, 1896.

Vol. 16, 1888, pp. 19–20; Ballou, Howard H.: "The chinook wind," *Amer. Met. Journ.*, Vol. 9, 1892–93, pp. 541–547 (gives short bibliography); Burrows, Alvin T.: "The chinook winds," *Yearbook U. S. Dept. of Agriculture, 1901;* reprinted in *Journ. Geogr.*, Vol. 2, 1903, pp. 124–136 (a fairly full discussion, with charts and diagrams); Henry, Alfred J.: "Climatology of the United States," *U. S. Weather Bureau Bulletin Q*, 4to, Washington, D. C., 1906, pp. 72–73; Abbe, Cleveland: "The wet and dry chinooks," *Month. Wea. Rev.*, Vol. 35, 1907, pp. 176–177; Bavendick, F. J.: "Blizzards and Chinooks of the North Dakota plains," *ibid.*, Vol. 48, 1920, pp. 82–83.

[15] Coe, A. B.: "How the chinook came in 1896," *Month. Wea. Rev.*, Vol. 24, 1896, p. 413.

Another account, by a former student,[16] is as follows:

> One need only stay for a short time in the Missouri Valley region of Montana to see the effects of the chinook—popularly called here "the Montana monsoon." At Great Falls the winds were preceded by three or four days of clear, cold weather, with the temperature ranging from zero to —20°. A general rise in temperature began with a slight wind from the southwest. Each day the winds grew stronger and the temperature rose. On the third day after the winds were observed I noted a temperature of about 40° for the whole of one day. I drove 24 miles one day across perfectly level bench land and it was remarkable with what steadiness the wind blew—not a gust or flurry was felt.

Again, from another correspondent in Montana (dated Butte, December 10, 1910):

> Here is something that actually happened one day when I was in Great Falls two years ago. There had been a cold spell for over a week; the temperature had fallen to more than —30°, and averaged —20° for the week. I shall never forget that cold week. We used to sit on the radiator in the office all day to try to keep warm, and when we got away from the radiator we were cold again in a few minutes. This particular day at about quarter past seven, when I went to breakfast, it was about —20°, and about 2 P. M. the temperature was well above 32°. The main street in Great Falls was water all over, where previously there had been several inches of snow. This chinook lasted three or four days, and it was nearly like summer while it lasted. A chinook will last from a few hours to a few days. It blows from the southwest, and is not only warm but also very effective in melting the snow.

General Characteristics of Chinook Winds

The chinook wind is a characteristic feature of the eastern slope of the Rocky Mountains in Montana and Wyoming and as far south as Colorado. It is also noted, but has not been as well studied, elsewhere in the northern mountain regions of the Northwest, as in the Black Hills of South Dakota, in eastern Washington and Oregon, in northern Idaho and in other places. Occasional rather doubtful occurrences have been reported even farther east, quite well out on the northern plains. As fuller meteorological observations become available for this area, many occurrences of this wind, not heretofore discussed, will come to light. The late Professor Cleveland Abbe pointed out that a chinook-like wind also appears along the eastern base of the Appalachians.

The chinook is a warm and dry wind, similar in all respects to the Swiss *foehn*. Its direction along the eastern Rocky Mountain slope is in general southwest, *i.e.*, it blows from the mountains out onto the plains, but its direction is determined by the topography. It begins at any hour, day or night. In velocity it varies from a gentle breeze to a gale. It may blow steadily for many hours, or come in shorter spells interrupted by much colder and calmer inter-

[16] Thompson, Henry S., dated Butte, Montana, Dec. 23, 1905; unpublished.

vals. It may last three or four days. It usually begins as a succession of light breezes. Extraordinary stories are told regarding the warmth of the chinook, and this feature is abundantly established by reliable instrumental records. Coming after a spell of intense cold, it is often described as soft and balmy "like a summer zephyr." The preceding temperature may be 20° or 30° below zero and the rise frequently amounts to 20° to 40° in fifteen minutes. Professor Abbe reported a case at Havre, Montana, March 7–8, 1900, in which the thermometer rose suddenly, shortly after midnight on March 7, from 11° to 42° in three minutes. After remaining nearly stationary for several hours, the temperature fell from 44° to 18° in three minutes, and in 20 minutes more, it fell to 11°. Between about 5 and 6 A. M. on March 8, it rose from 20° to 40.° After a few hours it began to fall rapidly again, and in an hour and a half dropped from 43° to 9°.[17] These rapid fluctuations are due to the alternation between the warm chinook and the general conditions of cold which assert themselves as soon as the chinook ceases to blow. There is a surging back and forth of the cold air which normally covers the lowlands in winter, and which is temporarily displaced by the warm air of the chinook. Many other instances of remarkable temperature changes might be cited. Occasionally changes of nearly 100° take place within a few days. A rise of as much as 40° in 15 minutes is, however, rarely attained. The maxima during chinook winds are seldom over 40°, but a rise from below zero to 40° or 45° in a few hours is clearly a very marked phenomenon, and one which inevitably has important economic and physiological effects. Isolated areas of relatively high temperature may thus be produced where chinook winds are blowing along the eastern base of the Rocky Mountains, and these "islands" of warmth occasionally appear on the regular daily weather maps if the warm winds happened to be blowing at the time of the regular 8 A. M. (Eastern Standard Time) observations on which the weather map is based.

The sky is usually fair or clear over the plains during a chinook, but over the mountains down from which the wind blows, dark "chinook clouds" are seen, and at the summits and on the farther slopes rain or snow may be falling. Burrows has pointed out that the chinook does not always follow the mountain slopes closely as it descends, but may be blowing on the upper slopes, passing aloft across a belt at the base, and then appear again at the surface at some distance—100 or more miles—from the foot. Under such con-

[17] Cleveland, Abbe: "Sudden temperature changes in Montana," *Month. Wea. Rev.*, Vol. 28, 1900, p. 115.

ditions, there is a belt of very low temperatures along the base of the mountains, with moderate temperatures higher up on the slopes and out on the plains. Travelers crossing the Rocky Mountains in Montana in winter often meet this phenomenon. The case is cited of an east-bound passenger train on the Northern Pacific Railroad which left the summit of the pass with mild weather and temperatures above freezing, and in half an hour had descended into a district where the temperature was — 13°.

Origin and use of the name "Chinook"

It appears that the term chinook as applied to a wind was first used in western Oregon and Washington, and also in British Columbia, to designate a warm, moist southwesterly wind coming from the general direction of the district formerly inhabited by the Chinook Indians on the lower Columbia River. It was, perhaps, quite independently of this particular use of the term, applied by early settlers along the eastern base of the Rocky Mountains to the warm dry wind descending the eastern slopes of these mountains, which was then, and unfortunately still is, thought by many persons to owe its high temperature to the warm waters of the Pacific Ocean. The name is often applied at the present time to the warm, damp southwesterly winds on the coasts of Washington and Oregon, but its use should be limited to the warm and dry descending winds, of distinct *foehn* type.

Weather Map Types Favorable for the Occurrence of Chinook Winds

The general pressure distribution favorable for chinook winds along the eastern base of the Rocky Mountains in Montana and adjacent districts is a high over the central Plateau and a low moving eastward from British Columbia to Manitoba, and appearing on the United States weather map to the north of the northern plains. Such a condition results in a general flow of air from the southwest, across the mountains, and then down onto the lowlands to the east, the steepness of the barometric gradient determining the velocity of the wind. Chinook winds may blow at any time of the year, but they are most common in winter because the pressure distribution is then most likely to be favorable and because the temperature changes are then most marked and noticeable. A fairly persistent anticyclone (continental high) is a characteristic of the Great Basin region much of the time during the winter months, with cold weather. When, at the same time, the pressure is low on the eastern slope, conditions are favorable for the blowing of chinook winds and hence for mild weather, in the latter region. Chinooks will

occur on the western slopes of the mountains whenever the gradients are such as to cause a flow of air across the ranges to the west, but up to the present time they have received far less attention than has been the case with those on the eastern slopes, where they are more common because most of the cyclonic storms pass eastward along the northern boundary from the Alberta district. The reason that these winds do not occur farther to the southward is to be found partly in the difference in the cyclonic and anticyclonic controls, and partly in the more uniform temperature distribution in lower latitudes. They have been described as far south as southern Colorado, where they occur when a low pressure area or trough extends farther south than usual along the eastern base of the Rocky Mountains.

Origin of the Warmth and Dryness of the Chinook Wind

There is no mystery about the high temperature and the low relative humidity of the chinook. The explanation given forty years ago by Hann of the Swiss foehn applies equally well to the American chinook. There is no importation of warmth from the Pacific, any more than there is an importation of high temperatures by the Swiss foehn from the Sahara, as was once supposed. Under the prevailing pressure distribution, the air of the chinook is forced to descend rapidly from the mountain tops to the lowlands. In doing so, it is warmed dynamically and its capacity for water vapor increases, so that it becomes relatively drier. Free air observations have shown that the temperature aloft is even higher than that at the surface.

Economic Aspects of Chinook Winds

During the colder months, chinook winds are important factors in the local climates of the northwestern mountain states. They temper the severity of the winters, bringing welcome relief from the extreme cold and, when they occur often, distinctly raising the mean monthly and annual temperatures. The most marked temperature changes which take place during the winters of western Montana are due to chinook winds following severe cold. But it is their extraordinary effect in melting and evaporating the snow which has attracted the most attention. It is impossible to overestimate their economic importance to the cattle interests, as is pointed out in the graphic description of a chinook quoted at the beginning of this section. The coming of a chinook at a critical period saves thousands of cattle from starvation and freezing. The warmth melts the snow, as one correspondent expresses it, "just as though hot water or steam were directed against it." Because of

this wind, stockmen can get through the winter with much less stacked hay than would otherwise be required. Domestic and other animals exposed to the severe winter weather outdoors without shelter are not only able to secure food because of the chinook, but find in its warmth a welcome relief in their hard fight against the cold.

Evaporation and melting are so rapid that a foot of snow may disappear within a few hours, being "sucked up from the ground" without even a trickle of water, as one description has it.[18] At Helena, Montana, a snow-cover 10 inches in depth has disappeared over night, leaving a dry surface the next morning. In mid-winter as much snow will disappear during a few hours of mild and balmy chinook weather as would melt in the same number of days of the usual spring thaw. Chinooks aid greatly in keeping the railroads free from snow-blockades and, by favoring a melting and then a freezing of the snow in the mountains, they store up water in the form of ice for summer irrigation. The chinook, to quote Burrows,[19] "is an ever-welcome guest, whose coming is indicative of good, and whose absence would be a momentous evil." There are, on the other hand, a few drawbacks. In the case of many persons the warm dry wind has unpleasantly stimulating effects on the nerves, and because of the dryness, chinook weather is considered especially dangerous by the fire patrols in the national forests.

Winds of Chinook Character in California: "Northers" and "Santa Ana"[20]

A marked climatic characteristic of the Valley of California is an occasional strong northerly wind which, during the warmer months of late spring, summer and early autumn, has desiccating qualities which cause it to be much dreaded by farmers and fruit-growers. This "norther" derives its drying power from the fact that it has been dynamically warmed by compression during its descent from the Siskiyou Mountains to the north. In other words

[18] *Month. Wea. Rev.*, Vol. 35, 1907, p. 176.

[19] Burrows, A. T., *loc. cit.*, p. 136.

[20] See "Meteorology in California," *Amer. Met. Journ.*, Vol. 3, 1886–87, pp. 206–209; Campbell, Archibald: "Sonora storms and Sonora clouds of California," *Month. Wea. Rev.*, Vol. 34, 1906, pp. 464–465; Blair, Thomas A.: "Northers of the Sacramento Valley," *ibid.*, Vol. 37, 1909, pp. 132–133; Carpenter, F. A., and Garthwaite, J. W.: "Memorandum on air drainage in the vicinity of the Corona district, Cal.," *ibid.*, Vol. 42, 1914, pp. 572–573 (gives photographs of a norther dust cloud, and of a hygrograph record during a norther; also weather map showing pressure distribution favorable for northers in southern California).

it is of chinook nature. It blows when the pressure is highest to the north, and usually lasts from one to three or four days. During the summer months this norther is very hot as well as dry. It often seriously injures vegetation, drying fruit and scorching and killing young leaves. The soil dries up and cracks. Human beings suffer from nervousness and headaches, and become irritable and impatient. It is said that in the early days in California, if a murder or any personal violence resulted from a quarrel which occurred during a norther, that fact was taken into account as an extenuating circumstance. During a norther, cattle are restless and cows are reported to give less milk than usual.

In southern California, in the vicinity of Los Angeles, the "norther," under topographical control, may blow from northeast or from other directions. It is locally known as the Santa Ana because of its association with the pass and river valley of that name. In San Diego County the hot dry wind comes from the east. If such a wind blows at a critical time in the life of the fruit trees, in spring, it may do considerable damage.

Carpenter and Garthwaite have published an excellent photograph of the dust cloud preceding a norther in the Los Angeles district.[21] With increasing velocity of the wind, this cloud becomes thicker and more extended, and finally obscures everything. At Claremont, Pomona County, California, at 4 P. M., March 18, 1914, the relative humidity during a norther was recorded on the hygrograph as 5 per cent. with a possible error of 4–6 per cent. In four hours it rose to 97 per cent. with the cessation of norther conditions.

[21] Carpenter, F. A., and Garthwaite, J. W.: *loc. cit.* Fig. 3.

NEW VISTAS OF ATOMIC STRUCTURE

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IF, O gentle reader, you are by vocation or avocation scientific, and of that type of mind which believes imagination should not be given rein save in the formation of scientific hypotheses; if you hold the powers of ten vastly more informing towards infinity than any other kind of human language—be constrained not to peruse these pages. This exposition is designed rather for those in modern business and professional life in whom the spark of romance yet lives and who would still keep acquaintance with the gods of Olympus.

These indeed are days when one can know but little of the world save in the limited field of his own pursuits. So highly specialized have our professions become that many of us are living in a different age, and a world apart from our fellows. We can not read the language of their textbooks and technical publications —nor can they read ours. Under such conditions we can maintain the peerless treasure of an open mind only by continually cultivating contacts, superficial at best, with the realms of others' thoughts and lives.

If you could but hear this story from the lips of one, who, burning with the self-kindled flame of genius, has traced his meteoric trail through the vast dark region of atomic cosmogony, you might indeed be held enthralled by the recital. Such men, however, follow lonely lives and lofty thoughts in silence. They seldom speak in periods attuned to mankind's common ear. If now and then some one among them of less solitary temperament can pause, and, like Antaeus of old, touching mother earth, voice those thoughts that all ages and races of men have understood, then alone can others be brought into that palace of dreams where we abide.

The average physicist, especially if endowed with the rather practical bent of the engineer, occupies most of his time in the basement, between the floors and in the wall spaces, with the plumbing of our civilization. Sometimes he digs deep into the earth for contact with the sources of supply. Sometimes also he ascends to the roof and makes an opening that looks towards the sky and sees the stars, but excursions like these are usually taken only by the master artisans of the craft, by Kelvins, Rayleighs, Michelsons or Ruther-

fords. Fortunately, indeed, for all the rest, every hole that is made by them remains and the humblest apprentice may look through it forever after.

Our life, however, is spent for the most part, not star gazing, but with tools and torches—with cement and solder. Our imaginations are well disciplined, and our facility in argument acquires much inertia, because our laboratories are dedicated to the discovery of facts, and not to the discussion of opinions, and because these facts do not appear except as the result of much tabulating of numbers and of long and arduous calculations. This veil of mathematical complexity constitutes a nebulous fog through which vision for the majority is entirely obscured. Even the most experienced are led astray at times by the warped perspectives and the misty exaggerations of such a medium, and to no one time or generation has it yet been given to view the whole. Ours are disappointments that come to the traveler whose journey through a beautiful mountain region is limited to a few days, and who encounters a spell of rainy and foggy weather for that time. Our imaginations have anticipated the vista, the immediate foreground suggests it, and we glimpse it through a momentary lifting of the veil, but our time of departure from the scene approaches and the clear view is still withheld. Under such circumstances the real woodsman then finds contentment in the little clearing around his fire. This region is replete with beauty and interest. Mushrooms, ant lions, arbutus and mosses, tiny complexities of plant and animal life can fill a recreation period with quite as much interest as mesas and monadnocks, distant ranges and valley vistas.

With his mechanic's tools, however, the physicist has achieved results of great significance in our social structure. He, primarily, is to be held responsible for the deadly efficiency and the killing pace of modern life and all of the ills that these things bring in their train. With radio and long distance telephone ever reaching out their tentacles, the business man can no longer remain on this planet and escape the activities of commerce. If high-powered cars and concrete highways, airplane post and passenger service in a pinch may enable him to crowd a week's activities into a day, so that all his time for meditation and reflection has disappeared, he may thank us. Because we are able to double plant production and treble dividends our star just now is in the ascendant, but it is not so generally appreciated, however, that we have at the same time made it highly probable that if another world war should arise, the struggling governments will be able with either a handful of devoted men or by purely mechanical means to annihilate at a stroke large portions of each other's centers of population, men,

women and children without distinction. Society, still medieval in its ethical and political evolution, is in possession of weapons and forces, forged by us, that hang suspended over it, like the sword of Damocles, by the threads of our frail statesmanship, political ignorance and incompetence and public and private greedy enterprise.

What a marked contrast between this outlook and the beauty of nature's pageant, as it is being unveiled in the realms of the inorganic! Here we find perfection—finished, flawless, final. Our spirits buffeted and baffled in the eager restless strife of living—in the passionate, pitiful activities of mankind—here find themselves transported to a world of things impersonal and dispassionate, to an era far removed from the travail of evolution, into an element where storms and tempests are unknown. Chance, the blind goddess, rules here. Probability, whose myriad forms alone are equal to the reckoning, is all in all. She is not, here among her own, the captious creature that we recognize mixing up the affairs of men, marshalling vigitillions to our units, so vast her sway that error is no more. For eons that are past, and eons that are to come her laws are followed true, no variation, no exception, no omission, no mistake. With vastly greater differences among her subject atoms than exist among the races of mankind, her laws suit all alike. Little credit have we of the twentieth century for the recognition of this divinity!

It was Democritus of Abdera (460 B. C.) who first saw in the disappearance of water from a crock as it evaporated a manifestation of the atomicity of things. Recognizing as equally unthinkable the infinitely divisible or the finitely indivisible, Democritus made the more practical choice of the latter as a hypothesis and called the finitely indivisible *a-tomic*. Two thousand years before Lavoisier, he preached the indestructibility of matter. He left no school of disciples, none but Empedocles amplified his physics and chemistry, and when twenty centuries later Boyle, Rumford, Joule and Clausius turned again to think about physical problems, it was to begin where Democritus left off.[1]

What, then, has modern thought done by way of adding to the Atomic Theory of Democritus? First, these atoms have been endowed with motion, and very recently have been subdivided.

The first contribution can be regarded merely as an amplification of the ideas of Democritus—indeed, he must have thought about it. Rumford and Joule were faced with the necessity of accounting for the constant amounts of heat that appeared as the invariant result, when the same quantity of mechanical work was

[1] *Cf.* Carl Snyder, "The World Machine," for an interesting discussion of Democritus from which we have rather freely quoted.

expended, and seized upon molecular motion as a hypothesis; mechanical energy on a molar scale being transformed to the same identical kind of mechanical energy but on an atomic or molecular scale. Joule[2] also saw that the picture of a confined body of gas consisting of myriads of elastic points flying at random, each having a minute mass, and because of its velocity a minute momentum, would supply a simple mechanism for the observed laws of gases. The pressure imparted to the walls of the containing vessel would simply be the integrated momentum shocks of all these particles as they rebounded from collision with the walls. Heating the gas, if interpreted as raising the molecular velocity, would increase the pressure as demanded by the experimental fact. Compressing the gas by crowding more molecules into the same space would increase the number of impacts and raise the pressure in the direct ratio that experience had shown was the case.

Now, if an hypothesis fits and supplies an explanation of the group of facts for which it was designed, this indicates discrimination on the part of those who formulated it, rather than that the hypothesis contains any intrinsic content of abstract truth. As is usually the case, more careful experiments in this field showed that the facts for which the kinetic hypothesis was designed were not exactly correct. Quantitative work did not bear out the original computations. Here we find the acid test of any hypothesis. Must we now discard it altogether and build anew, or will careful scrutiny show that it may be amplified somewhat or applied a little differently? Joule had for the sake of simplicity of computation (to a physicist a most valid excuse) taken mathematical points for his molecules—making the leap of infinite divisibility unthinkable to Democritus. Clausius now took the same picture, but, postulating the natural assumption that the molecules must themselves occupy space and that each must exclude at all times all others from itself, he showed that this more sensible point of view when investigated numerically would lead one to expect exactly that departure from the simple relation of the gas laws that careful work had shown to exist. For exactness, we must add that the existence of attractional forces between these molecules had also to be included to give the result indicated. But this, too, was a very sensible, indeed almost inevitable, assumption, since we knew that mass in the gross attracts all other mass, and in the minute coheres together with great tenacity.

Furthermore, when a physical fact can be expressed in algebraic form, a purely mathematical operation on that equation may result in its being transformed into another equation which may in turn

[2] Bernouli is credited by some with having anticipated Joule.

have an interpretation sought in physical phenomena. Such phenomena may have been hitherto quite unsuspected. We are led to them not by direct contact with nature, but by the mysterious rites of symbolism, which here contain, however, nothing more deadly than logic. If, in the spot where the symbols say the treasure lies, we delve, and find not only treasure (for treasure lies wherever one digs), but those specific articles of value that the formula foretold —our hypothesis, glorified into something that is more than merely the creation of our minds, lives transcendently, outlasting the mind that fathered it and perhaps the age and race of men that knew its birth. It is the expression of one of those immutabilities of the universe that have existed and will exist forever.

Thus, from the parenthood of atomic ideas, the kinetic theory of heat born in 1840 has now found its place in the sun. Yet up to 1914, such is the temper of the scientific mind, one of our most illustrious chemists, Wilhelm Ostwald, was still skeptical, preferring to think of energy rather than matter as atomic. In the new edition of his "Outline of Chemistry," however, we read:

> I am convinced that we have now become possessed of experimental evidence of the discrete or grained nature of matter for which the atomic hypothesis sought in vain for hundreds and thousands of years. . . . The atomic hypothesis is thus raised to the position of scientifically well-founded theory.

In other fields of scientific endeavor one can observe quite parallel cases. The Copernican theory of the solar system that makes the sun and not the earth the center, and the Pasteur theory that many diseases are caused by micro-organisms and may be combated better by the destruction of the cause than by prayers to the saints, also rest scientifically on the same kind of evidence. They have struggled up to the light against the same type of opposition, and are now to be considered as imperishable monuments of this last great scientific era.

The second addition that has been made to the ideas of Democritus has come but very recently. Its shadow, however, like that of all great things, preceded it afar. Eighty-eight years ago, to the eternal glory of England, Michael Faraday discovered that if equal quantities of electricity were passed through a conducting solution there would be deposited out weights of material that were strictly proportional to the relative weights of the atoms involved. Thus, he identified with each atom a definite quantity of electricity, and this quantity was the same for all atoms of the same chemical nature. Atoms of different chemical nature or valence had associated with them two or three or some other small and exactly integral number times this fundamental quantity.

The charge associated with each chemical atom in solution was later discovered to exist in gases under special conditions. It was but twenty years ago in the *Philosophical Magazine* for March, 1902, that Kelvin, under the whimsical title "Aepinus Atomized," said: "My suggestion is that the Aepinus (electric) fluid consists of exceedingly minute, equal and similar atoms, . . . much smaller than atoms of ponderable matter." This electric atom and every integral multiple of it up to about two hundred, has been isolated and counted not once, but many thousands of times during the last ten years by Wilson, Millikan and others. These experiments which establish the atomic nature of electricity are mentioned by Ostwald in the quotation abridged above as having convinced him finally of the atomic nature of matter itself. Indeed, they are utterly inexplicable on any other hypothesis.

Thomas A. Edison, during the early stages of the development of the incandescent lamp, observed mysterious currents that passed through the highest possible vacuum from a glowing filament. These currents could not be attributed to the presence of charged atoms in a region from which the atoms had been almost completely removed. Through the work of Lenard, Crookes, Lodge and especially J. J. Thomson, these currents have been found to consist of tiny electric atoms shot out from the matter in which they normally reside and traveling with velocities of from ten to one hundred thousand miles per second. These electric atoms, called "electrons" first by Johnstone Stoney, possess other properties in keeping with their prodigious speed of emission. They are capable of deflection in a magnetic field and this deflection shows not only that the charge they carry is negative (*i.e.*, similar to that obtained on sealing wax when rubbed with fur), but also enables us to measure the ratio of the charge to the mass, e/m. Knowing the charge carried by the individual electron from independent experiments, we can thus divide out and obtain the mass. This mass we are familiar with as being 1/1845 part of the mass of the lightest known atom, hydrogen.

Of very great significance also is the fact that whatever may be their source—whether they are released by light action from the surface of zinc or of potassium or many other metals (the so-called photoelectric effect), or liberated by high temperature from wires of tungsten, platinum or filaments of carbon (the Edison effect) or shot out at much higher velocities of over 180,000 miles a second during the spontaneous disintegration of a radioactive element, which itself may be either a heavy metal, an active alkali or an inert gas—these electrons are in all respects absolutely alike. It would appear then that we have here a common material from

which the 92 different varieties of matter we call the elements are built.

By years of patient study, weighing, combining, substituting one substance for another, re-weighing and weighing again, the chemist has taken the almost infinite number of different things on and in the soil of our earth and found them all to be combinations of less than one hundred different substances, the elements. The romance of the details of this story is enchanting but can not be touched on here. Pushing the field of exploration ever further the chemist ultimately found himself at every turn baffled by a fact undoubtable, inexplicable and vastly intriguing. There was a rhythm in these elements. If arranged in a row beginning with the lightest and proceeding to the heaviest, it was seen that at equal intervals along the line there were recurrent similarities between these fundamentally different things. Newlands, first, and Mendeléeff, finally, with the greatest completeness formulated these "octaves" in the periodic law. The recognition of this law caused rapid extension of exploration in chemistry, because its general character pointed out how and where to work. The explanation of the law remained for generations an utter mystery.

However, with the discovery of electric atoms of a more elementary nature than the elements, the clear light dawned for chemistry. We now recognize in the elements, as we progress from light to heavy, structures fundamentally electrical in character, as foreshadowed by Faraday, and built up from simple to complex by a process that we are soon apparently to understand.

And, as the spectroscope first showed to man that in all the starry sky those mighty suns were as ourselves composed of but stone and iron and hydrogen and oxygen and clay, that we in true chemical sense were fashioned as the image of the Almighty, so now in these same "cosmic crucibles," thus aptly named by Hale, do our spectroscopes read the appalling swing of inorganic evolution. Vast as was the time required for our race to emerge from the slime of the Proterozoic seas, this interval is but one stroke of that cosmic clock that measures the birth in a star, first of hydrogen and helium, and then little by little as the cycle goes, the further cementation of the building material into lithium, boron, carbon, oxygen and iron, and, later still, the union of these and others into oxides, compounds, rock and stone. Irresistible is the suggestion that life itself must also be there somewhere between the stages of incandescence and eternal cold. Thus, in the pageantry of the sky we are permitted to glimpse into the eternity of future and of past, and see the two unite as they vanish.

Matter then contains and essentially consists of atomic structures, each an aggregate of more minute atoms whose nature is that

of negative electrification. Is this all? If so, you may be formulating the question, How, then, are these electron systems to be held together? Electrification, we have always been told, repels other electrification of like kind. Is our hypothesis going to remain forever at variance with this elementary and obvious fact? For quite a long time indeed we have been baffled by this very question. Our hypothesis has appeared hopelessly hemmed in from the light by this very wall. The early postulates of Thomson of uniform spheres of positive electrification, through which the electrons swim, were admittedly guesses for the sake of simplifying computations. The breach has now been made, however, by Rutherford and his brilliant associates. Through it the light comes streaming, and every number of our journals is replete with new material confirmatory of the general features of our point of view, and supplying many new hitherto unsuspected details that may be fraught with great importance ultimately to all mankind.

One of the radiations given off by radium and many other radioactive substances has long been known to consist of particles charged two units positively and having a velocity of about 18,000 miles per second. These alpha particles, as they are called, are over 7000 times as heavy as the electron, and yet can plow through hundreds of thousands of other atoms and create no disturbance. They will come through a glass wall for years at a time and leave no holes. They must be accordingly inconceivably minute compared with the atoms themselves, or else the structure of the atoms must be such that they are penetrable, as is the solar system by an occasional comet. On exceedingly rare occasions, however, we observe an alpha particle completely fail to get through another atom, and a little oftener we see it swung out of its straight line of flight by such an encounter. The dynamics and geometry are simple, and compel the conclusion that a positive nucleus exists at the center of all atoms, minute beyond conception, but charged and massive. This positive nucleus established by direct experiment is the dominating sun, as it were, of this tiny planetary system. With it must be associated practically all of the system's mass—the planetary electrons contributing but very little. Here, as in exterior cosmogony, we find the inverse square law of Newton still dominant. Other great names recur. A Darwin has shown that the inverse square law of repulsion is the *only* law compatible with Rutherford's experiments. Furthermore, the central forces in this nucleus are proportional to half the atomic weight which is, as a matter of fact, the number that represents the position of any element as it stands in rank and file in the chemical table. Hydrogen, the first, occupies a unique position; helium, the second, weighs

four; lithium, third, weighs six plus; beryllium, fourth, weighs eight plus; boron, fifth, weighs ten plus; carbon, sixth, weighs twelve, exactly; nitrogen, seventh, weighs fourteen, to one part in 1500. The atomic ordinal number, then, is about half the atomic weight. It is regarded nowadays as of much greater significance than the atomic weight itself.

From an altogether different angle we have recently found a method of attack. Equipped with diffraction gratings by Rowland and by Michelson, the spectroscope has revealed to us not only the chemical composition and physical conditions of the stars, but their velocities and sizes as well. Thus are we able to formulate the fascinating story of stellar evolution. Similarly adaptable in the microcosmos, the spectroscope in its early form has given quite independent testimony not only of the kinetic dance of molecules and atoms, but very definite hints as to the nature of the electric mechanism which constitutes their essence. To Laue of Munich the idea first came that in a crystal nature had supplied us with a grating a thousand times more fine than Michelson could ever hope to rule, and endowed it with the perfection that nature produces as a matter of course and man strives in vain to imitate. The crystal spectrograph extended our vision by revealing the true nature of the X-Ray as light of extremely short wave length.

During the early years of the war, there was at the Dardanelles, among those boys who met death with laughter on their lips, a British soldier by the name of Moseley. His brain, pierced by a Turkish bullet, had made contributions to our knowledge of X-Rays, which, aside from his valor, will ever rank him among immortals. These contributions are as far removed from the shadowgraphs of Roentgen as the measure of a giant sun by a Michelson interferometer is from silhouettes traced by shadows on a screen. Moseley discovered that there is revealed a relation of utmost simplicity between the wave lengths of corresponding lines in the X-Ray spectra of different elements and the atomic numbers of these elements. Even the constant that the formula contained, Bohr has shown to be not empirical but demanded by the superposition of the fields of the nucleus and those of the planetary electrons. Thus the ballistics of Rutherford's projectiles are given quantitative verification by the optics of Moseley.

J. J. Thomson first pointed out how altogether clumsy were the most refined methods of the chemist in the matter of determining atomic weights which appeared in many cases to be hopelessly at variance with these more recent contributions. Refining the methods of Goldstein, whose mysterious "canal rays" turned out to be nothing more recondite than streams of flying atoms, Thomson now

weighs the atoms directly by hurling them with prodigious velocity through electric and magnetic fields and measuring by photography how they swerve from the rectilinear. The most important result so far of the positive ray work of Thomson has been the discovery of the isotopes, which has laid forever the ghost of atomic weight discordancies.

There exists in our atmosphere, discovered by Ramsay, a rare gas comprising but 1½ parts in a hundred thousand of the total. It is inert, enters into no combination with any other substance, and was called by its discoverer "Neon." Neon's atomic position of ten demanded twenty for its atomic weight. Chemical methods showed indubitably that it weighed 20.2 and the 1 per cent. error has remained intolerable. Thomson has discovered that there are two neons, one weighing exactly twenty and the other exactly twenty-two. The latter is very much less abundant than the former but is inextricably mixed with it, and the measured weight has only the significance of an average value.

Since neither of the forms of neon possess any chemical affinities, it might at first sight appear as if the difficulties of the usual chemical methods for separating them were here exceptionally great. However, when this positive ray method was applied by Aston, and more recently by Dempster, to other elements whose weights were obviously discordant, there have been found two kinds of lithium, weighing exactly six and exactly seven, two kinds of boron, ten and eleven; three kinds of magnesium, 24, 25 and 26; four kinds of zinc, 64, 66, 68 and 70; and no less than six kinds of mercury, ranging from exactly 197 to 204. These different varieties of an element, or isotopes, differ in weight alone. Their other physical and chemical properties are identical. However, substances of different mass diffuse at different rates and partial separations of the isotopes of mercury and of chlorine have been made in sufficient quantity by Harkins to amply confirm these most sensational results. Why sensational? Because, if all the atoms are found to have simply related integral weights we have in this fact a necessary and sufficient argument to suggest a simple structure in that part of the atom with which the weight is associated, namely, the nucleus. Thus the atom is composed not only of electrons added one by one about its central nucleus, but this nucleus itself is a structure built more compactly but in accordance with a plan definitely related to the exterior and of the same essential entities.

Prout, as long ago as 1815, formulated the doctrine that all atoms were constructed of hydrogen, but this was little more than speculation suggested by the approximately integral character of the atomic weights. The scientist of the nineteenth and twentieth

century is not of the temper to dignify speculations that will not bear quantitative investigation. Here, however, is something strongly suggestive of what Prout had in mind, but formulated against a vastly richer background. Moreover, the doctrine of nuclear structure is not now without additional experimental proof.

Transmutation, the age-old dream of the alchemist, has ever been a fascinating vision. With the discovery of radioactivity and the chemical and physical untangling of this most puzzling field, we learned that transmutation was indeed no dream but an actual reality. However, there appeared to be a sacred inviolability about the process which not only kept it hidden from all save the most discerning eye, but also showed it to be something which the hand of man could not control. All the power of a harnessed Niagara could not alter, accelerate or retard it. Subatomic forces and energy herein revealed were as far removed, it seemed, from human contact as a distant nebula. To look and to marvel was permitted, but not to tamper. Rutherford, however, in his Bakerian lecture at the close of 1920 announced that by directing alpha particles from radioactive Thorium C against nitrogen atoms, positively charged hydrogen atoms are released. These have greater energy than when released by similar experiments in hydrogen itself, and can not, therefore, come from hydrogen as impurity in nitrogen. Moreover, they possess mass for mass; energy greater by as much as 40 per cent. than that of the alpha particle that gave them birth. Likewise, from boron, fluorine, sodium, aluminium and phosphorus has this intrepid experimenter more recently obtained similar results. What is left of the element nitrogen after it has been so disintegrated has not yet been determined.

Now these positively charged hydrogen atoms really are the hydrogen nuclei themselves, since all evidence shows us that one electron is all that is ever associated with the neutral atom. In these we recognize at last the electron's alter ego, and we have named it "proton." Charged positively by the same amount that the electron is charged negatively, the resemblance can not be carried further. One, 1,845 times more massive than the other, paradoxical as it appears, this strange couple, ill matched in everything except their perfect affinity for one another, are in all likelihood at the root of all matter.

Neutral hydrogen contains the simple pair, proton and electron, but such an atom is unsymmetric and does not exist, except transiently without uniting with another. The neutral molecule thus formed has its two electrons revolving in some manner, as yet unknown, about the line between its two nuclei. Helium has, within its nucleus, four protons closely associated with two electrons giv-

ing the necessary weight of 4 and residual charge of 2. Far outside the region of the nucleus are found the two external electrons. Here again the dynamics of the system is as yet but dimly seen. One or both of these electrons may easily be detached or disturbed. When so disturbed, the periods with which they vibrate are of enchanting beauty of color and possess an alluring simplicity of equation. Without its two electrons the helium nucleus is a marvelously stable system. This it is that we called first the alpha particle. Shot out from many radioactive explosions the stability of these helium nuclei is in no way affected even when they impinge on other atomic systems with sufficient energy to disrupt the latter. They are thought by some to constitute a secondary building unit. If this be true, all multiples of weights of 4 in the table should be singularly stable. No. 8 exists; but 12, carbon, 16, oxygen; 20, neon; 24, magnesium; and 28, silicon, are the only elements which have so far withstood Rutherford's attempts at disintegration. Similarly, if we do succeed in disintegrating these or any other elements, we should expect to get out of them helium nuclei in no inconsiderable amounts.

The recently much discussed experiments of Wendt, in which helium was thought to be found as the result of high temperature explosions of tungsten, are to be mentioned in this connection, although of too preliminary character to be yet recorded as a positive result.

Finally, let us offer a few crude illustrations of the scale of these things as contrasted with our own stature. The various powers of ten, in terms of which physicists think in this connection, have been purposely omitted, since to the average man a million, 10^6, even in dollars, is but an idle dream.

The size of an atom, if inverted and expressed in dollars, would make a nice little nest egg for the establishing and running of a university. The size is a hundred millionth of a centimeter, 10^{-8}. This is utterly beyond the most powerful microscope of this or any other age to discover, since our seeing is conditioned ultimately, not by our instruments, but by the size of light itself. With a good car, and a concrete road all the way, by driving an average of 200 miles a day, steadily without holidays, one would arrive at the moon in three years and five months. Try to imagine a group of investigators from a race of supermen with stature such that while standing on the earth their heads would be on the moon! In other words, let their six feet of stature expand to a quarter of a million miles, and let their laboratory, their alpha particles, their hydrogen, helium and other materials be built on the same scale. If we were now admitted to this giant world, the smallest atoms would appear quite

conspicuous to us, being spheres of about four inches in diameter. They would consist of impenetrable regions from which we and all other atoms would be excluded by the presence of terrific repulsive forces. Involved in an impact, their inertia would still be only about that of a gram weight.

Within this four-inch sphere, what would we see? If it were hydrogen, there would be the proton nucleus and the electron—nothing else. The electron would hardly be called conspicuous. In spite of the prodigious magnification we would still need a good microscope to find it. Its diameter would be but a ten thousandth part of an inch. The nucleus we could never hope to find. Its diameter would be about one ten millionth of an inch, so much smaller than a light wave, that no image of it could be formed.[3] Thus it appears we have not magnified sufficiently.

Making the nucleus large enough to see, let us suppose it to be one inch in diameter. The attendant electron would be 85 feet in diameter and swing in an orbit 170 miles across. For perspective let us compare such a system with our solar system, and alter the scale by even a more prodigious ratio. If the electron were the size of our earth its orbit about the central nucleus would have to be almost ten times as large as that of the earth. It would swing out in the vicinity of Saturn, 800 million miles away. The nucleus would be utterly invisible until one got quite close to it, for its diameter would be but four miles even on this cosmic scale. A man in this proportion would more than bridge the entire known universe of stars. Thus one can see that even the heaviest atom with its central nuclear pack of protons and electrons, possibly as great as one thousand miles in diameter, is for the most part empty space. Relatively great forces pervade this space. But other systems, if endowed with sufficient energy to overcome the existing repulsions, can pass right through and in general produce no disturbance.

External space is not nearly so filled with solar systems as internal space is with atoms. A beam of light will traverse our solar system in three quarters of an hour, but three and a half years is required for it to reach our nearest neighbor star. In the realm of atoms, however, the average separation of the systems in a gas like hydrogen at atmospheric pressure is only about 500 times their own diameters. If the stars were as dense, we would encounter one about every twenty days if we traveled on a beam of light. In

[3] The size of the proton (hydrogen nucleus) is quite problematical as yet. If its mass is due to charge distributed over a spherical surface in accordance to ordinary laws it must be a thousand times smaller than the electron, *i.e.* about 10^{-15} cm. The text is in accord with this estimate.

The nuclear pack of heavier elements, composed as it is of electrons and protons, is thought to be of same order of size as electrons themselves.

liquids and solids the packing is closer, although the systems are not in contact, the separation being of the same order as their own size. The number of these little systems in a cubic inch of atmosphere is appalling, 10^{19}. If all the people of the United States should by agreement try to count this number, each individual counting five per second, throughout each 24 hours, it would take our population of a hundred million souls over a thousand years to complete the task.

These are stupendous facts. As facts alone, however, they do not possess their greatest interest. Their significance in relation to our social order is the vital question for thoughtful men and women. Scarcely 150 years have passed since Franklin with a kite drew electricity from a cloud. Harnessed now, this modern genie of the lamp has become a slave to do our bidding. Deeply from the cup of knowledge also has it given us to drink. Clear heads and sober minds are needed, as never before, to watch lest the genie prove an evil one providing us with weapons for our own destruction.

The dreams of Jules Verne, that fired the imagination of our boyhood, incredible as they then appeared, are to-day in many instances accomplished facts. And, while natural conservatism, bred of scientific training, decries the possibility of our ever being able to unlock in quantity the stores of atomic energy, infinitesimal portions of which have already been released, we know not what the future holds. In H. G. Wells we have a contemporary writer, undoubtedly as well informed of the scientific tendencies of his time as was Jules Verne. Can it be that in his writings, also, there runs a vein of prophecy (using "prophecy" only in the sense of extrapolation from the curve of human progress in the past, which would indicate its probable course in the years to come)? Certainly, one who has seen the dreams of Verne fulfilled can not but shudder at Wells's horrible pictures of future civilization, enmeshed and entangled in the harness that science even now is forging.

But, after all, the curve is ours to alter. No predestination impels us towards destruction. As individuals in social and political life, we must keep pace with science; and, taking warning from the fate of Moseley, prevent the repetition of another such orgy of destruction as that which recently was detonated by the monumental stupidity of our so-called civilization.

For the present let us hope that the peak rate of scientific progress has been passed—that education and the broadening sympathy that comes from true culture may grow apace—to the end that man may see, and, growing in wisdom, reverence the incomparable perfection, the radiant beauty, the undeviating rectitude and the eternal character of the universe in which he lives.

A FLIGHTLESS NEW ZEALAND BIRD

By Professor DAYTON STONER
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Of the many peculiar and bizarre types of birds found in the world probably none is more unique or interesting than the apteryx or kiwi of which there are but five or six species, all confined to the Dominion of New Zealand.

About three or four hundred years ago a group of large flightless birds, some as much as ten to eleven feet high, roamed over the volcanic hills of this land. The aborigines of the country pursued these great moas, as they were called, destroying them for food and perhaps also making use of some other parts of the body. So persistently were these giant birds persecuted that to-day not one exists and we know of them only through legends and the remains that have been found. However, their miniatures, in certain respects, are represented in the present fauna of the islands by the vanishing kiwi.

Only a few of these birds are left in the hills and more or less inaccessible bush of North Island, South Island and Stewart Island. Of late an endeavor has been made to protect the species all over the dominion and efforts toward conservation are being effected. Some of the zoological parks are so fortunate as to possess a specimen or two, the individual described in this article being, at the present moment, a captive in the well-kept park at Wellington. It is an example of the North Island kiwi, *Apteryx mantelli*.

One morning, in company with the keeper and Mr. Harold Hamilton, of the Dominion Museum staff, I visited the portion of the park reserved for this curious bird. Along one side of the low shaded enclosure flowed a small creek; near the middle of the area was a heap of sticks and brush, but nowhere was the kiwi to be seen. Entering the wire-netted compound and kicking at the pile of sticks the rather bedraggled and forlorn appearing occupant was soon dislodged and with reluctant and awkward gait it made off toward a shady corner, where it remained for a time quite motionless and apparently dazed by the bright rays of the sun.

One is at once struck by the strange appearance of this tailless and all but wingless creature. It is about the size of a domestic fowl; it has a rounded and compact body; the neck is short, but the bill is long and slender; the legs are short and powerful. Add to

KIWI IN WELLINGTON ZOOLOGICAL PARK, WELLINGTON, NEW ZEALAND
(Photo by Dayton Stoner)

located near the *tip* of the six-inch, semi-cylindrical bill, a condition which prevails in no other bird. Numerous stiff, bristle-like feathers cover the face and base of the bill.

this the much reduced wing, totally useless as an organ of flight, and the body covering of long, "stringy," hair-like feathers of a brownish or grayish-brown cast and the appearance of this singular bird is rendered still more un-bird-like. Indeed, the North Island kiwi can scarcely be considered beautiful.

The kiwi may truthfully be said to have the longest "nose" of any known bird, for the slit-like, ventrally placed nostrils are

The lower leg is covered with irregular, horny scales, and the three long, strong front toes are furnished with heavy, sharply-pointed claws. A small first or hind toe is also present.

When handled, our zoological park kiwi showed resentment by hissing and kicking—not backward so much as forward—and with sufficient force to cut one's flesh deeply. It offered no resistance with the formidable-looking bill.

Kiwis are hardy, nocturnal birds which hide in holes or dark places during the day and come out at night to feed mainly upon earthworms and also, to some extent, upon vegetable material.

Under natural conditions a hole in a bank or under the roots of a tree is chosen as a nesting site and, in a burrow, partly natural, partly excavated by the female, the one or perhaps two white eggs

are laid. In proportion to its size the kiwi lays the largest egg of any living bird, a female twenty-five inches in length producing an egg five inches long and three inches broad. The birds will breed in captivity, the individual under discussion having laid eggs which, unfortunately, were destroyed before hatching by the flood waters of the adjacent stream.

Contrary to the general rule among birds, the male incubates the eggs and after a period of about six weeks the helpless young are hatched. They acquire strength rapidly and in a few days are able to join the parents in searching for food.

A very well-executed habitat group, showing one egg, three young and four adults of the North Island kiwi, is exhibited in the Auckland Institute and Museum.

It is to be hoped that such satisfactory protective measures for the kiwi may be taken by the New Zealand government that it will be in no danger of the fate that has befallen its even more remarkable precursors, the moas.

THE PROGRESS OF SCIENCE

By Dr. EDWIN E. SLOSSON
SCIENCE SERVICE, WASHINGTON

MOTION PICTURE OF ATOMIC COLLISIONS

Staging a collision between locomotives is an old movie stunt but Professor W. D. Harkins, of the University of Chicago, has gone to the opposite extreme in setting up a camera that will take pictures of the tracks of the atoms through space and their occasional collisions.

Since the atomic particle to be photographed is only about a million millionth of an inch in size and is moving at a speed of ten thousand miles a second, taking its picture is more of a feat than filming a slow-coach locomotive that may be making a mere sixty miles an hour. To work out a way to do it required an alliance of Anglo-Saxon and Japanese brains, the "Wilson-Shimizu apparatus," it is called. In this ingenious contrivance advantage is taken of the fact that when moist air is cooled suddenly the water is precipitated from the air in the form of dewdrops that deposit upon the walls of the vessel or upon any electrified particles, such as dust, that may be floating in the air.

Now the smallest of all possible electrical particles is that known as the electron, which is so minute that it would take 1,840 of them to weigh as much as the smallest atom, the atom of hydrogen. These electrons are more or less loosely attached to the atoms of all kinds of matter; so loosely in fact that you can rub some of them off a piece of glass with your handkerchief as is shown by the fact that you have "electrified" the glass.

We can get free electrons from air by knocking them off the atoms of nitrogen by bombarding them with what are known as "alpha particles." The alpha particles are the fragments of helium atoms thrown off when the metal radium decomposes. They carry a double charge of positive electricity and are projected from the exploding radium atom at a speed some twenty thousand times as fast as a rifle bullet. Their momentum is so great that they plunge right through the atoms they encounter and may travel several inches through the air before they are slowed down, leaving behind a trail of some 200,000 fragments of nitrogen atoms. These fragments being electrified may each form the center of a minute dewdrop. If now a bright light be thrown on the screen from the side, the track of the alpha particle will be seen as a shining line of illuminated drops, and may be photographed.

But once in a while the flying alpha will do more damage to an atom than carry off one of its outer electrons. It may chance to hit an atom in its central nucleus, where most of its mass is concentrated, and so smash it to pieces. Now the nucleus of a nitrogen atom is made up of hydrogen and helium and either of these may be dislodged. In Professor Harkins's snapshots we can see the result of such a collision. The alpha particle has bumped up against the nucleus of a nitrogen atom and bounded back, while the dislodged fragment of the nucleus is projected forward, so the track appears to fork.

SPENCER FULLERTON BAIRD

The distinguished naturalist, from 1850 to 1887 assistant secretary and secretary of the Smithsonian Institution, the centenary of whose birth has been celebrated this year

THE CHEMISTRY OF A SKYSCRAPER

The first thing that attracts the attention of the newcomer as he sails up New York Bay is the imposing group of tall buildings, unequalled elsewhere in the world. As he looks up at one of these strange structures he thinks of the architect who planned it and of the builder who constructed it.

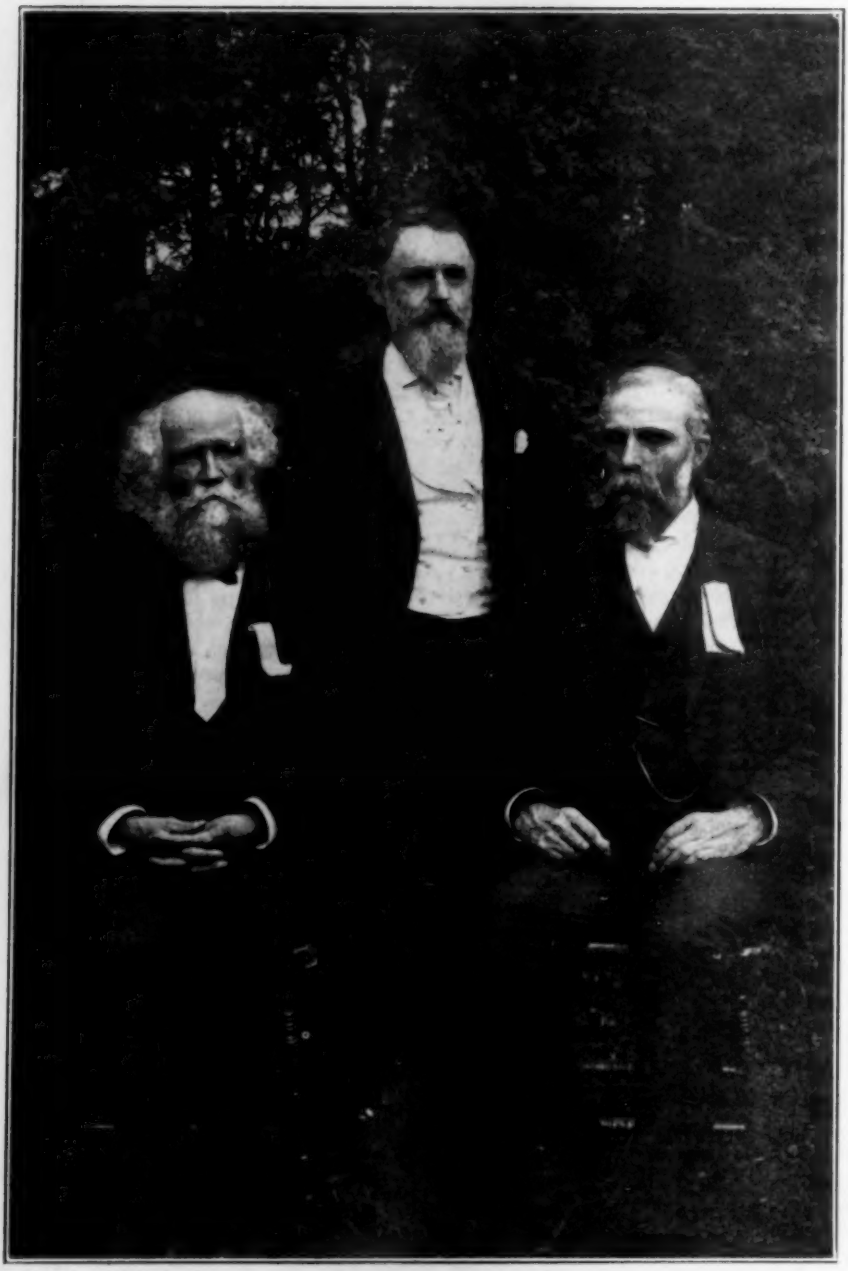
But he does not think of the chemist who is behind them all and without whom it would be impossible to erect and equip a skyscraper. He made the ink and paper with which the architect drew his plans and he made most of the materials that the builders use. For even what seems to be natural material will be found on closer examination to have passed through the hands of the chemist. The doors and casements may be grained to look like wood but tap them and you find them steel. There may be a coating of natural stone on the side facing the street, but this is a mere concession to conventionality, for the building is mostly composed of cement, concrete, brick, mortar, plaster, terra cotta, tiles and glass, all of which are manufactured by chemical processes. The skeleton of the skyscraper is of steel, something not found in nature. The furnishings and electrical equipment are made largely of brass, bronze, tin, aluminum, rubber, celluloid and the like, all chemical products. So are all the paints and enamels that adorn and preserve the walls and metal work.

In the skyscraper work goes on by night as well as by day, for rooms are lighted by electric currents flowing through wires of a new metal, tungsten, enclosed in glass bulbs from which the air has been exhausted and perhaps replaced by some inert gas. The chemist not only provides for fire in the form of matches, but he also furnishes the means of putting out fire if it gets out of bounds. In the halls you will see a fire-extinguisher ready, at the turning of a tap, to throw out a stream of water and quenching gases.

If you look into a shop window on the lower floor you will see gay garments, colored with dyes prepared from coal-tar and in many cases made from artificial fiber that rivals silk in sheen and beauty. In the corner drug-store many of the medicines are also prepared from this same coal-tar which once was thrown away or burned up as good for nothing. The chemist provides the weapons with which the doctor wards off the attack of microscopic enemies of mankind, the microbes.

The roots of the skyscraper go down deep in the ground and are embedded in the solid rock. But it would not have been possible for the building to have been dug so deep if the chemist had not provided explosives. The nitrogen gas which he extracted from the air and fixed in the form of dynamite or gunpowder returns to freedom with such violence as to rend the rocks.

In the top-story of the skyscraper there is probably a restaurant, to take advantage of the lofty view, and there, too, the chemist plays an essential part. Cooking is a chemical process and so also is cooling, which is almost as important to the modern chef. The foreign fruits and perishable meats have been preserved by artificial refrigeration by means of ammonia made from the nitrogen of the air. The china, the glass, the cutlery and the kitchen utensils are all chemical manufactures. The vegetables are grown by the aid of chemical fertilizers, containing potassium, phosphorus, nitrogen and lime. The foods and drinks are analyzed in the market so as to see that they contain no dangerous impurities or adulterants. The water supply of a great city has to be watched from day to



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Officers of the American Association for the Advancement of Science, Rochester Meeting, August, 1892

day lest it should be visited by some deadly epidemic. If the old saying is right that "cleanliness is next to godliness," then the chemist stands next to the preacher, for he invented soap many centuries ago and has now added more powerful agents of purification, such as chlorine.

The automobiles which wait in front of the building are propelled by gasoline and oiled by lubricants manufactured from crude petroleum, and their wheels are tired with rubber vulcanized by the chemist.

In some large hall of the building you may very likely see motion pictures of events that happened far away and long ago, caught, preserved and displayed on celluloid film, made from gun-cotton and camphor and developed by coal-tar chemicals. You may also hear music from unseen singers and players, permanently recorded for the pleasure of posterity, on disks of synthetic resin. The radio apparatus on the roof, almost entirely composed of chemical products, receives messages and music from a thousand miles away through trackless space.

So science short-circuits both time and space, bringing the past into the present and enabling us to chat with distant people as though they were in the room. And the chemist has a hand in all the achievements of science because he possesses the peculiar power of transforming matter into strange and useful forms. From colorless, odorless air and water he can make substances harder than marble, colors more brilliant than natural dyes, flavors rivaling the fruit, and perfumes as sweet as the flowers. For the chemist deals with the minutest things in nature. He can control the atoms, and even the electrical particles of which the atoms are made, and by combining these in various ways he can construct new things, unknown in nature, and contributing to the comfort and convenience of modern life in innumerable and unrecognized ways.

THE ADVANTAGE OF TAN

The Ethiopian cannot change his skin but the white man can. That is where the white man has the advantage, for when he is exposed to the sun he gradually becomes a colored man. (The negro is not a "colored" man; he was born so.)

The white skin automatically protects itself against the injurious action of the sun's rays by developing a layer of dark pigment in the deeper part of the epidermis. That is, the brunettes and the tannable blonds have this power. The incorrigible blonds that burn and blister will have to stay in the house or take to charcoal face powder.

Black looks black to us because it absorbs and keeps the visual rays of light. White looks white to us because it reflects them back to our eyes. White clothing is therefore better than black in the tropics because it sheds sunshine better. Black cloth absorbs about twice as much of the visible rays as white.

We might conclude from this that a white skin would be better than black in warding off sunshine. And so it would if heat were the only thing involved. But it is not. The sun's rays contain, besides the heat that we feel and the light that we can see, certain rays that we can neither feel nor see but which have a powerful effect upon the skin for good or ill. These are the rays that have a shorter wave length than the violet which are the shortest that can be seen. They are therefore called the "ultra-violet." Ordinary sunshine contains only about one per cent. of these ultra-violet rays; more if the air is dry, less if it is damp. Of the rest of the solar radiation about 19 per cent. is in the form of visible light and

Wide World Photos

A Large Family

Mrs. Martha Allbright Hankins, of Pine Bluff, Arkansas, who has recently celebrated her ninety-sixth birthday, is the head of the family. There were 245 members of the family present at this gathering to celebrate Mrs. Hankins's ninety-sixth birthday; 100 others could not attend. Among those who helped to celebrate the birthday were seven children, 62 grandchildren, 150 great grandchildren and 23 great-great grandchildren. Mrs. Hankins can be seen in the center foreground with a black bonnet.

about 80 per cent. in the form of dark heat or "infra-red" rays. The heat rays are absorbed about the same whether the skin or clothing be black or white.

But with the short-wave rays at the other end of the spectrum it is different. These are more energetic than the long-wave rays but are more easily discouraged and do not penetrate so far into the skin. If you hold up your hand and look through it toward the sun you will see that the light that gets through the thin parts of the fingers looks red. That means the long red waves, and of course the longer heat waves, go through the flesh while the short violet waves, and of course the shorter ultra-violet, are caught and held in the flesh.

This is fortunate for the ultra-violet rays are fatal to the living cells of the body. The X-rays that have waves ten thousand times shorter than the ultra-violet are so powerful that they are used to burn away cancers. The visible rays of short wave length are still strong enough to cause sunburn.

What we need then in the skin is some sort of a contrivance that will take these short light and ultra-light waves and transform them to the harmless heat waves, what the electricians call a "step-down transformer."

Well, we have such a contrivance in tan. First the thin horny outside layer of the skin catches and converts to heat the ultra-violet. Then the short-wave visible rays, violet and blue, are caught by the pigmented cells lying beneath. The longer waves, the yellow, red and infra-red, penetrate further but do no harm except to make us warmer. A thin-skinned person well tanned is better off than a thick-skinned person because the former is sufficiently protected against the lethal rays and yet get rid of his own internal heat more readily by radiation through his thin skin.

The tan serves a purpose other than mere protection. For the nerve endings lie between the pigment cells and when they are excited by the heat from the transformed light they dilate the vessels in the skin and so send out the sweat which by evaporation cools off the body.

It seems that ultra-violet and violet rays may be positively beneficial when properly transformed by a coat of tan. Rickets and tuberculous sores are reported to be cured by the exposure to direct sunlight but not by that which has been passed through glass for this filters out the ultra-violet rays.

It is not necessary to carry the pigmentation to an extreme as the negro does. A good browning will insure against the injurious and secure the beneficial effects of sunning.

HOME-MADE RUBBER

It is to be hoped that part of the half million dollars that Congress has recently appropriated for developing a domestic rubber supply will be devoted to investigating the possibilities of home-made, as well as of home-grown, rubber. It is all right to start rubber plantations in the Philippines. If we had done that ten years ago we should not now be at the mercy of the British rubber-growers. Let us also milk the milkweed if it can be induced to give down. But let us further give the chemist a chance to see what he can do in the way of competing with the agriculturist. He has beat him on madder and indigo. Perhaps he can do it on caout-chouc.

We know that rubber can be made in the laboratory. At the International Congress of Applied Chemistry held in New York shortly before

the war the German chemist, Duisberg, proudly exhibited in the Great Hall of the College of the City of New York a pair of tires that had been made from synthetic rubber and had run an automobile a thousand miles or more. The British chemist, Sir William Perkin, promptly countered with a different process for making artificial rubber. Neither process has so far proved a commercial success but the chemists have not given up the problem.

Last year Plotnikoff announced in a German periodical that caoutchouc chloride could be readily made by the action of ultra-violet rays on vinyl chloride. Now the caout-chouc chloride can be easily converted into ordinary rubber and vinyl chloride can be made from acetylene which, as every automobilist knows or used to know, can be made by dropping calcium carbide into water, and calcium carbide can be made from coal and lime by the electrical furnace and the electrical power can be got from waterfalls.

But where can we get the ultra-violet rays? There are plenty in the sunshine but they are pretty well filtered out by the atmosphere before it gets to us, luckily, for otherwise we would get worse sunburned than we do. The mercury-vapor lamp, such as makes us look like corpses when we are having our photographs taken, gives off ultra-violet but that is too expensive.

Now the ultra-violet rays differ from the rays that we can see only in having shorter wave lengths. Sometimes we see a tall man walking with his short wife, both at the same gait but she taking two steps to his one. So all kinds of light travel with the same speed in empty space but the violet takes two steps to the red's one, and the rays beyond, that is the ultra-violet, step faster still.

But a polite man will shorten his pace to accommodate the lady he is walking with, even if she is his wife. Can not light of long wave length be induced somehow to shorten its wave? In other words, can not ordinary sunshine be converted into ultra-violet light, or at any rate be made to act the same? It can in various ways, and Plotnikoff has shown that if a salt of uranium is added sunlight will serve as well as ultra-violet in effecting the transformation to rubber.

There is nothing absurd about making rubber with sunlight. All the rubber we use is made that way. And if a tree can use sunshine for that purpose why can not the chemist? We have plenty of sunshine, more than most countries and more than we want in summer. If there can be devised satisfactory step-up transformers to change sunshine into ultra-violet rays we might make not only rubber but a host of other things for which we now depend on plants, and we could use this energetic agent for speeding up numerous chemical manufactures. Dr. S. E. Sheppard in the February issue of the *Chemical Age* suggests that we might in time beat the plants in the making of various oils, resins, gums, sugars, dyes and drugs. The American Association for the Advancement of Science, foreseeing the immense future importance of knowing how to utilize the constructive power of light, has appointed a special committee on photosynthesis.

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